African Indigenous Knowledge Systems in Climate Change Adaptation and Mitigation: An African Young Scientists Initiative

Editors: Hassan O. Kaya & Yonah N. Seleti
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Edited by
Hassan O. Kaya
Yonah N. Seleti

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It was at this conference that the African Young Scientists presented their papers for this important publication on the role of African indigenous knowledge systems in climate change adaptation and mitigation.

Special appreciation also goes to Ms. Anke Weisheit who worked tirelessly to bring the African Young Scientists together and Dr. Livingstone Makonde for the initial compilation of the papers.

Hassan O. Kaya
Yonah N. Seleti
Preface

The publication of this work by the African Young Scientists Initiative on Climate Change and Indigenous Knowledge Systems is based on the understanding and acknowledgement that African Indigenous Knowledge Systems (AIKS) that have been locally tested and are culturally acceptable have sustained the lives of African people over centuries against adverse effects of climate change such as drought, floods, famine, diseases, etc. This great contribution tends to be neglected in the current global search for sustainable solutions to climate change.

There is, however, a growing global recognition that the effects of climate change are serious, urgent and growing. Simultaneously, the role of African community-based knowledge systems, African young scientists and the youth in general are becoming increasingly prominent. It is on the basis of these assumptions that Africa’s responses to and actions with regard to this global challenge will be judged by history. If Africans fail to meet this challenge boldly, swiftly and in unity, they risk consigning future generations to an irreversible catastrophe. No country, however large or small, wealthy or poor, can escape the effects of climate change. Rising sea levels threaten every world coastline; powerful storms and floods threaten every continent; and frequent drought conditions and crop failures create hunger and conflicts in areas already threatened by poverty. Experience shows that for too many years, humanity have been too slow to respond to or even recognize the magnitude of the threats of climate change. It is also true that for many years we have failed to recognize the important role that African indigenous knowledge systems and African young scientists and youth in general can play with regard to the promotion of sustainable solutions to climate change.

Research studies in different parts of the developing world including Africa’s own experiences have demonstrated that in local communities, the world over, community-based knowledge systems in weather forecasting have been used as the basis for local-level decision-making. These local knowledge systems have value not only for the local cultures from which they arise, but also for scientists and planners striving to improve conditions in rural and poor localities. African local communities and farmers in their
respective environments have over the years developed intricate systems of gathering, predicting, interpreting and decision-making in relation to the weather. Community knowledge-holders base their seasonal predictions on close observation and understanding of weather patterns, and the behaviour of plants and animals before the onset of rain. Prediction of impending disasters has been an integral part of their adaptation strategies.

In spite of all these and related benefits, there is a need to acknowledge that the role of African Indigenous Knowledge Systems in climate change is hampered by several limitations that pose a great challenge to African young scientists involved in this field.

The challenges include among others:

- A lack of proper documentation: As the old people who hold this valuable knowledge pass away, their knowledge and insights, which has been accumulated for many years, are lost. The old pass their accumulated knowledge orally from one generation to the next.

- A lack of coordinated research to investigate the accuracy and reliability of indigenous knowledge forecasting: Indigenous Knowledge weather forecasting is constrained because it applies over a small area (local specific) and cannot be extrapolated to other areas. Therefore, the applicability of such knowledge in other localities to complement scientific weather forecasting needs to be investigated.

As the developmental engines of the 21st century in Africa and in their fight against the challenges of climate change, African young scientists and youth in general must not allow the old divisions that have characterized the climate change debates for so many years to block progress. The developed countries which have caused much of the damage to our climate over the last two centuries still have a responsibility to lead and support sustainable initiatives to prevent climate change. These countries should also continue to do so by investing in renewable energy, promoting greater efficiency and slashing emissions to reach the targets set for 2020 and the long-term goals set for for 2050.

It is very encouraging to see that the articles contained in this publication demonstrate that African young scientists from different parts of the continent have already taken up the challenge to document, publish and share their research experiences with the international community. They
gathered at the Kopanong Conference Centre in Johannesburg from August 29-31 2011 for the International Student Conference on Climate, and at the COP17 UN Conference on Climate Change in Durban (2011) in the Round Table Discussions on the Role of Indigenous Knowledge Systems and African Young Scientists on Climate Change. This global stage is a challenge for them because they are from African local communities and many are versed overwhelmingly in the cultures of their communities.

The impetus driving this initiative is also based on the observation that African Indigenous Knowledge Systems were marginalized during Africa’s colonial past because the logic of colonialism was mainly to exploit Africa’s indigenous natural and human resources for the benefit of the colonial powers. The relevance and sustainability of indigenous African ways of knowing contradicted the colonial world views of domination and exploitation. Unfortunately, in the era that succeeded colonialism we have inherited certain colonial practices and views which have perpetuated the marginalization of African Indigenous Knowledge Systems (AIKS) as primitive and unscientific. This legacy limits our search for sustainable solutions to development, including the challenges of climate change. In spite of their relevance to local community conditions and livelihoods, until recently, AIKS have not formed part of the national educational curricula of most African countries and are not taken seriously in their national and provincial sectoral developmental policy-making processes.

The marginalization of AIKS reflects the marginalization of African rural communities and other poor communities in general, the majority of whom depend on AIKS for survival. The neglect of these community-based knowledge systems, therefore, has had consequences vis-à-vis the lack of control of Africa’s own development. Moreover, a large proportion of the African population is under 25 years of age compared with western countries where ageing populations are the norm. Therefore, Africa cannot afford to be governed with the same government mechanisms and strategies as those of western countries. This means that African policy-making processes and policy implementation mechanisms and strategies have to reflect the integration of the youth in that context, otherwise Africa will fail to reach its potential. This is the challenge. Further, climate change is a multi-sectoral challenge and cannot be approached in mono-sectoral perspective. This reflects the importance of AIKS, by which Africa can contribute to global scientific knowledge, and which links science and technology to Africa’s public policy processes. If Africa cannot do that, it will not reach the values of developmental ownership and it will repeat the colonial and existing post-
colonial ideas and practices that marginalizes AIKS in the search for sustainable development.

However, this publication emanating from the African Young Scientists Initiative on Climate Change and Indigenous Knowledge Systems testifies to the growing realization, both within and outside Africa, that Africa’s investment in the future and in sustainable development must focus on young people. African young scientists are challenged to facilitate the production of knowledge that will be relevant to African communities by learning and working directly with them, in particular with their knowledge holders. The importance of promoting the role of African young scientists and youth in sustainable development, including climate change adaptation and mitigation, has also been emphasized in the African Youth Charter of the African Union in its various articles and The New Partnership for Africa’s Development (NEPAD, October 2001) in its sectoral priorities. NEPAD’s Section B5 on Culture states that it gives special attention to the protection and nurture of indigenous knowledge systems for sustainable development in Africa.

The publication will make an important contribution to further research and also provides reference materials for the teaching of AIKS and climate change, at both undergraduate and postgraduate levels.

Hassan O. Kaya
Yonah N. Seleti
Introduction

Hassan O. Kaya
Yonah N. Seleti

The adverse effects of climate change on sustainable development, food security, and livelihood in general, have been the centre of discussions during major international conferences on the environment. These started with the Earth Summit in Rio de Janeiro in 1992 and was followed by the Kyoto Protocol of 1997. Following these two very significant world-historical events, work progressed through to the World Summit on Sustainable Development in Johannesburg (2002), the United Nations Climate Change Conference in Copenhagen or COP15 (2009), and the United Nations Climate Change Conference in Cancún (2010). This publication was inspired by these very significant events and is the product of an initiative by African Young Scientists (AYS) from different parts of Africa. It is the result of papers delivered at two events in Africa, viz. the meeting at the Kopanong Conference Centre in Johannesburg from August 29 - 31 2011, and the African Young Scientists’ Round Table Discussions on Indigenous Knowledge Systems (IKS) and Climate Change at the COP17 United Nations Conference on Climate Change in Durban (2011). These young scientists have already made substantial contributions to the developing discourse on sustainable development and are committed to the promotion of the role of IKS with regard to how especially African Indigenous Knowledge Systems (AIKS) articulate with climate change adaptation and mitigation.

In line with these world conferences on sustainable development and climate change, the Millennium Development Goals (MDG – cf. the 2013 Report) adopted by world leaders in 2000 provide concrete, numerical benchmarks for tackling extreme poverty in its many dimensions including environmental protection. For example, the MDG Target 7 seeks to promote the integration of the principles of sustainable development into national
policies and programmes, reverse loss of environmental resources, and reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss. The achievement of the MDGs with regard to environmental issues and climate change is very significant for Africa because it is the most vulnerable continent with a rich biodiversity.

It is against this background that we herewith introduce this volume. We have done so under three themes. These are:

- **THEME 1:** Indigenous Knowledge Systems (IKS) in Climate Change Adaptation and Mitigation
- **THEME 2:** African Indigenous Knowledge Systems, Food Security and Health in Climate Change
- **THEME 3:** Indigenous Knowledge in Climate Change and Natural Resource Management

In the remainder of this Introduction, we shall provide a brief overview of the main contributions under each of these thematic headings.

**THEME 1: Indigenous Knowledge Systems (IKS) in Climate Change Adaptation and Mitigation**

Issues dealing with climate change and climate variability have been dealt with and analysed across various disciplines, and decisions made based on climate science. Such decisions have applied mostly to communities within urban setups. In most cases the vulnerable people within rural communities have been left out in the process. Until now not much of indigenous knowledge systems have been established and made use of in climate change adaptation strategies. In her chapter titled, ‘Integrating Indigenous Knowledge Systems into Climate Change’, *Juliet Gwenzy* focuses her paper on understanding available indigenous knowledge, the challenge of semantics across cultures, while paying particular attention to community experiences so as to give them salience. The flexibility with which humans communicate is developed into cultural schemas and these form indigenous ontologies that are then used to address the issue of semantic interoperability of indigenous knowledge across cultures. By making meaning of the
Introduction

contextualized indigenous knowledge, the paper proposes ways of collecting and incorporating the finer details of community experiences into climate adaptation strategies. In this way the communities make contributions to the development of tailor-made adaptation processes which are closer to home, and much related to the experiences of indigenous populations. A conceptual framework is designed which integrates scientific methods to indigenous knowledge repositories. The chapter also highlights the importance of social responsibility from which the best mechanisms are provided for effective communication, dissemination of best adaptation options using a demand driven and a bottom-up approach. To tie the systems together, an evaluation of introduced scientific strategies against indigenous strategies is done. It demonstrates the role of indigenous knowledge in climate change adaptation strategies.

In her ‘Interaction of Indigenous Knowledge Systems with Climate Change Adaptation and Mitigation in Uganda’, Jacquiline Nassali points out that Climate change (CC), the alteration of long-term weather patterns through human activity, is a problem currently affecting the world with dire consequences especially in developing countries in Africa. These countries are projected to be among the most affected in the next 20 years (PFCC 2011). Literature has documented that farmers in Uganda seek information to anticipate the inter-annual variability in the timing and amount of precipitation, a matter of great importance to farmers since they rely on rain-fed agriculture for food supplies and income. Further, the effective use of indigenous knowledge (IK) by academia, development institutions and more importantly farmers could provide the solution to climate prediction. Against this background she argues that the increasing attention IK is receiving by academia and the development institutions have not yet led to unanimous perception of the concept of IK. In this light, her chapter seeks to demonstrate the importance of traditional/indigenous knowledge regarding CC adaptation and mitigation, outlining some of the various IK systems used to protect natural resources and biodiversity in the past, present and possibly future. She also analyses the effectiveness of the use of IK in Uganda. The Government of India in 2001 set up the Traditional Knowledge Digital Library (TKDL) as repository of 1200 formulations of various systems of Indian medicine. Similarly, South Africa has setup documentation and digital data systems for her traditional knowledge. What is required is that Uganda
does the same. Yet it first has to focus on programmes to re-invent and organize traditional knowledge so that it can meet some standards for the protection of the environment. A study needs to be undertaken on the possibility of evolving a system for protecting traditional knowledge. Programmes of research, documentation and digital data systems for Uganda’s traditional knowledge should be developed as has been done in India and South Africa.

The contribution by Hasan O. Kaya and Yonah N. Seleti, ‘Cultural Values and African Indigenous Knowledge Systems in Climate Change Adaptation’ is based on a study that examined cultural values and African indigenous knowledge systems in climate change adaptation and interpretation. It is argued that western scientific explanations of climatic change have mainly concentrated on anthropogenic, greenhouse gas emissions while indigenous African knowledge-based interpretations of observed climate changes are often much more varied and encompassing. It emerges that in some local communities the media and its coverage of climate change dominate local people’s understanding. These local, personal observations and experiences evoke deeply felt emotions as familiar signs of seasonal changes become uncoupled and in-validated by modern media. The wealth of indigenous knowledge based on decades if not centuries of observing and working with the natural environment is orally transmitted. It needs to be documented in order to contribute to the global pool of knowledge and climate change policy development.

In the face of climate change and variability in semi-arid Ghana, small reservoirs offer reliable source of water for multiple uses to improve food security and reduce poverty. Past shortcomings in planning and investment approaches have led to uncontrolled investment costs often making small reservoir projects more expensive. Nonetheless, donor agencies continue to invest in small reservoirs, perceived as a more viable adaptation strategy to climate change. In their ‘Evaluating Small Reservoirs as Option for Climate Change Adaptation Strategy and Sustainable Rural Livelihoods’, Ernest Nti Acheampong and Jean-Philippe Venot examine the development process of small reservoirs and their impact based on their performance, and contribution to mitigating of climate change effects and the improving of
rural economic livelihoods. Despite some level of success, most of the small reservoirs have performed below expectation. Their contribution to the economic livelihood of users has not been remarkable given the substantial investment in small reservoir development. Both technical and managerial constraints have accounted for their poor performance. Analysis of the 135 out of 232 small reservoir sites (in the Upper East region of Ghana) that were detected by remote sensing in both the 1999 - 2001 and 2005 - 2006 landsat images indicated that the surface areas and the corresponding volumes of the small reservoirs were significantly lower in 2005 - 2006 than in 1999-2001. This was mainly attributed to the decline in rainfall in 2005 - 2006 since 1999 - 2001. Variation in actual storage can give some insights on the potential benefits of small reservoirs in a climate change context where rainfall is expected to decline (and surface runoff to increase). On average, the volume of water stored in small reservoirs was 12% lower in 2005 - 2006 than in 1999 - 2001. This is an indication that small reservoirs are effective buffers against drought, as can be expected. The effectiveness of small reservoirs to buffer rainfall deficits depends on the biophysical characteristics of the area (size of the watershed) and where they are located as well as on the design (notably, the spillway characteristic). The chapter suggests that in dealing with emerging challenges of climate change, small reservoirs development requires a comprehensive diagnosis of planning and technical designs that shape small reservoirs development, whilst understanding conditions under which small reservoirs can yield their full potential.

In their case study, Roxventa A. Ongugo and Samuel Kimani addresses ‘The Role of Indigenous Knowledge Systems in Climate Change Adaptation and Mitigation’ in the Mijikenda Community, Kilifi County, Kenya. Traditional knowledge systems are functional entities and institutions that serve as custodians of specialized areas of traditional knowledge and indigenous innovations. Traditionally, African farmers have used indigenous knowledge to understand climate and weather patterns, to make decisions about crop and irrigation cycles. Climate change affects many indigenous communities throughout the world. Environmental degradation resulting from increased human activity is a major threat, especially to forests, rivers and lakes and even farmlands in general. In their chapter, they focus on the Mijikenda community from the coastal part of Kenya. Over the centuries, the
Mijikenda have accumulated a wealth of knowledge in traditional resource-use and management systems, and associated practices and customs related to forests, agricultural and marine resource use. However, the Kaya forests (sacred forests) are still sacred ancestral landscapes, revisited for rituals and traditional prayers by the Mijikenda. For them, it is important to explore the role played by traditional knowledge systems in adaptation to climate change. Within coastal indigenous communities, focus group discussions with indigenous community members, and district forestry and agricultural authorities with strong emphasis on active reliability with traditional knowledge systems were used to collect detailed information among the Mijikenda living in Kilifi County. Analysis of the data was done using SPSS software. Findings from the study were presented using simple statistics. Qualitative analysis was used to show how traditional knowledge is used as a strategy in enhancing adaptation to climate change effects.

**THEME 2: African Indigenous Knowledge Systems, Food Security and Health in Climate Change**

Organic farming is a system that relies largely on locally available resources and is dependent upon maintaining ecological balances and developing biological processes to their optimum. Western emphasis on mono-cropping introduced non-native foods (pineapple, cabbage, spinach, carrots, etc.) which required extensive irrigation and frequent applications of pesticides and chemical fertilizers. In Kenya this is a non-sustainable form of agriculture, given the fact that 80 percent of crops are grown in the arid lowlands, where rain is becoming increasingly unreliable. In his chapter, ‘Using the Knowledge of Organic Farming in Addressing Challenges from Climate Change’ Eliud Magu Mutitu and John N. Wanjau argue that Long-term solutions to global warming, drought and crop failure must be addressed by reducing dependence on Western-style agriculture in favour of indigenous crops. He says that any comprehensive strategy for addressing climate change must include both adaptation and mitigation, and organic farming has the potential to do both. Resilience to climate disasters is closely linked to farm biodiversity; and that practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. Farming practices that preserve soil fertility and
maintain or increase organic matter, such as crop rotation, composting, green manures and cover crops, can reduce the negative effects of drought while increasing productivity (FiBL 2007). In particular, the water-holding capacity of soil is enhanced by practices that build organic matter, helping farmers withstand drought. Further, agriculture has the potential to change from being one of the largest greenhouse gas emitters to a much smaller emitter and even net carbon sink. Organic systems have been found to sequester more carbon dioxide than conventional farms, while techniques that reduce soil erosion convert carbon losses into gains.

In his ‘Indigenous Traditional Knowledge Pastoral Adaptation Strategies to Climate Change in Selected Area of the Cattle Corridor of Uganda’ Henry Massa Makuma argues that pastoralists’ communities have been able to use Indigenous Traditional Knowledge (ITK) to cope in various ways to climate change shocks. However, little is known of these ITK coping practices among pastoralists in Uganda. This study examined the major climatic shocks in the past three decades amongst agro-pastoralists and adaptation and ITK practices to the changes in climate in the cattle corridor of Uganda. Qualitative and quantitative data were collected mainly using individual and group discussions and interviews (individual, key resources persons). Quantitative data was analysed using the Statistical Package for the Social Sciences. Qualitative data was subjected to development of emerging patterns and themes for analysis. The major climatic shocks identified were prolonged and increased frequency of dry spells, cattle disease outbreaks, especially foot and mouth disease and contagious Bovine Pleuro-pneumonia (CBPP) disease. In response to the prolonged dry spells, the pastoralists’ constructed communal wells and dams, moved from one place to another, reared local cattle breeds and made changes in (cattle) feeding times. The implications of movement were the increased spread of diseases and death of cattle. Coping strategies documented were migration to relatively safe areas, quarantine, vaccinations, use of herbs, native diagnosis and treatment of animals. The Indigenous Traditional Knowledge (ITKS) described were the use of herbs, timing of feeding of animals and treatment. In conclusion, the pastoralists have endeavoured to adapt, however, their adaptive capacity needs to be enhanced and supported. It is recommended that the ability of pastoralists to harvest, store and efficiently use water as they minimize disease spread needs to be enhanced.
In their ‘African Indigenous Organic Farming as a Climate Change Adaptation Strategy’ Anke Weisheit and Hassan O. Kaya argues that organic farming has been practiced in Africa for centuries as an indigenous environmental conservation and climate change adaptation and mitigation strategy. African local communities using their tested local knowledge, skills and experience knew that organic farming has the potential to address the combined threat of climate change and other environmental stresses. It promotes the use of cultural, biological and mechanical methods as opposed to using synthetic materials. However, this community-based knowledge is tied to specific climatic conditions and cannot be transferred to other areas without due caution and modification including further research. Its success also requires a wider recognition among institutions that currently promote mainly conventional agriculture.

There are several factors that limit bean production and productivity in Malawi and among them is the limited availability of seed of recommended bean varieties that can cope with the current physical and economic effects of climate change. In her ‘Climate Change and Smallholder Agriculture: The Case of Sustainable Bean Production in Malawi’, Ruth Magreta used the participatory variety selection (PVS) approach in an attempt to put farmers first in identifying farmers’ bean variety preferences in relation to diverse agro-ecological and end-user systems. Through PVS farmers and traders had access to a range of varieties; they use their own criteria to choose varieties based on socio-economic and agronomic characteristics. At each PVS site, farmers chose varieties they preferred depending on traits exhibited in those varieties. Some of the traits liked by farmers included early harvests, dwarfism and pod load, which translate into high yields, resistance/tolerance to pests, diseases and drought resistance, etc. Men and women had their different preferences. Out of the potential 20 varieties tested on-farm and on research stations from 2006 - 2007 to 2009 - 2010 cropping season, three bean varieties have been released, namely NUA45, NUA 59 and VTTT924/4-4, using data generated from the stations as well as on-farm. Results have indicated that these varieties are high yielding as yields range from 1300kg/ha to 2000kg/ha. Furthermore they are resistant to diseases such as angular leaf spot, rust and anthracnose, plus they are rich in micronutrients like Fe (102ppm) and Zn (35ppm). With climate change, farmers are increasingly keen to obtain varieties that can withstand the whims of
changing weather patterns: early maturity, drought, heat, diseases and pests, and these varieties through PVS have been identified as an answer to the challenges. These results indicate that with climate change there is the need to make major shifts in varieties grown, cropping calendars and even growing seasons, which may also result in disappearance of some bean varieties that have existed for centuries.

Traditional medicine is widely used for the management and treatment of various diseases in African countries, especially in rural areas where conventional health care is not easily accessible. The World Health Organization (WHO) has estimated that up to 80% of the population in sub-Saharan Africa relies on traditional medicine to meet their primary health-care needs. In their ‘Climate Change Effects on Medicinal and Aromatic Plants Used For Primary Health Care in Uganda’, Francis Omujal, Henry Ralph Tumusiime, Moses Solomon Agwaya and Grace Kyeyune Nambatya, argue that with the emergence of diseases associated with climate change such as malaria, diarrhoea and respiratory tract infections, patients have turned to indigenous traditional healing methods using medicinal and aromatic plants (MAPs), vital components of biodiversity. Over-exploitation of MAPs for treatment of climate sensitive diseases and exposure to extreme weather conditions such as drought and floods have led to certain species becoming endangered. In addition, the effect of climate change also causes variability in the bioactive phytochemical components of MAPs. The vulnerability of Uganda to climate change effects has led traditional health practitioners, government and development partners in Uganda to focus on conservation of MAPs and building capacity on adaptation to climate change. Therefore, there is need to conduct further research on the effects of climate change on the sustainability of MAPs and their variability in bioactive phytochemical components.

Mpho Setlalekgomo’s ‘Effects of Changing Ambient Temperature on the Oxygen Consumption and the Body Temperatures of Adult Angora Goats’ points out that farmers of Angora goats in the Karoo area experience large stock losses during cold and wet conditions. Information on the thermoregulatory responses of the goats to cold and wet conditions is scarce. We recorded the oxygen consumption (VO\textsubscript{2}), body temperature (Tb), skin
temperature (Ts) and activity of six adult Angora weathers from the Karoo in the Eastern Cape, South Africa, at varying conditions of ambient temperature (Ta), fleece length and state of wetness. The experiments were conducted at ambient temperatures of 8°C and 20°C. For unshorn goats, wetness resulted in the elevation of VO₂ at 8°C, which is indicative of increased metabolic rate. The mean rectal temperatures of the goats were within the normal range (38.5 – 39.7°C) at 8°C and 20°C. Homeothermy was partly achieved by reduction of Ts, which reduced the temperature gradient between the skin and the air. For shorn goats, the reduction of Ts was 3 – 6°C between Ta 8°C and 20°C while rectal temperature was constant. Therefore the goats had to raise their VO₂ to maintain their normal Tb. However, the dry shorn goats at 8°C had lower VO₂ than at 20°C. It appears as if the goats abandoned endothermy and become torpid. There was no significant difference in activity of goats at different ambient temperatures. Activity of individual goats varied. The skin temperatures of the unshorn goats at 8°C and 20°C were more or less the same as were rectal temperatures. This suggests that the unshorn goats only used increased VO₂ to maintain their body temperature while the shorn goats used both VO₂ and Ts. It can then be speculated that the shorn goats were more susceptible to cold conditions than the unshorn goats which had less insulation and therefore enhanced conductance.

**THEME 3: Indigenous Knowledge in Climate Change and Natural Resource Management**

In his ‘Involving Forest-Dependent Communities in Climate Change Mitigation: Challenges and Opportunities for Successful Implementation of REDD+ In Tanzania’ Thabit Jacob states that forests play an important role in climate change mitigation as sources and sinks of carbon dioxide gas. The Norwegian and Tanzanian governments have recently agreed to cooperate with other non-governmental organizations and academic institutions to execute reduced emission through degradation and deforestation activities under REDD+ framework in order to reduce carbon emissions and minimize impacts of global warming. It is increasingly realized that to ensure successful implementation of REDD+ including all desired side effects it is crucial that the communities which depend on the forests are participating
Introduction

fully and that their rights are respected. Among the challenges faced in the implementation of REDD+ in Tanzania is the issue of participation of the forest-dependent communities. There are concerns that the massive influx of REDD+ funds could result in a sudden increase in the value of woodlands, and that REDD+ funds, while accelerating the process of declaring community forests, could also lead to massive land grabs in which communities would lose out. Both of these scenarios would have very serious implications for forest-dependent communities in Tanzania. Although seminars discussing the REDD+ initiative have been conducted with government representatives and donors, and a draft policy framework for REDD+ in Tanzania has been developed, until recently very little seem to be clear about the role of forest-dependent communities. This chapter highlights issues that need particular attention in order to make sure that REDD+ works in the interests of the forest-dependent communities. Full, effective and timely participation of forest-dependent communities in the REDD+ process at all levels can add value to the development of sustainable climate change mitigation and adaptation strategies that are rich in local content, and planned in conjunction with local people. Data collected originated from different relevant secondary materials whereas qualitative data analysis was adopted through critical discussion.

Tanzania like other countries in the world is facing climate change challenges whereby rural communities seem to be more vulnerable. Globally different research attempts to study climate change impacts tend to focus on the livelihoods of people at macro rather than micro level. In addition to the urban communities, Tanzania is composed of pastoralist and agropastoral communities who for years have and still do rely on natural resources for the survival of themselves and their animals. In his ‘Accelerating Community-Driven Initiatives toward Climate Change in Tanzania: Land Use Resource and Livestock Feed Conservation’ Elisha Felician says that research findings have revealed that climate changes greatly affect rural communities, especially those who depend on livestock and crop activities to support their lives. Different environmental conservation approaches have been undertaken by traditional people with little assistance from researchers and other stakeholders in natural resource conservation. The chapter is focused on community initiatives on climate change and on agro pastoralist livelihoods perspectives in Tanzania. Previous studies and reports have
identified inadequate forage and water supply due to poor management practices and available resources, aggravated by climate change. However traditional knowledge on natural resource management and utilization such as land-use systems, ngitili, and farmer’s altitude on water uses are common practices among agro-pastoral communities as they respond to climate change. Few projects have been reported to support the initiatives which have top-down approaches for newly introduced techniques. However, knowing community - driven initiatives from household level can facilitate a development-intergraded approach towards climate change and accelerate farmers’ ability to be less dependent and become more self-confident in participating in solutions to for their own problems. Considering the current situation of the pressure of availability of essential resource such as food, livestock feed and water, identifying traditional approaches can help establish practical and cost-effectiveness practices to support conservation and enhance techno-blended solutions towards climate change.

Kassim Ramadhani Mussa’s study, ‘The Perceptions and Experiences of Climate Change and its Impacts by the Traditional Communities of the Western Slopes of Uluguru Mountains, Morogoro, Tanzania’ was carried out to gather the perceptions and experiences of the Uluguru mountains communities on climate change and its impacts, and to understand their traditional innovations in detecting climate change and coping with the impacts. It took place in three villages of Luale ward, namely Luale, Masalawe and Londo in Mgeta division, Mvomero district. Participatory research methods were employed in generating the perceptions, information and experiences about climate change, its impacts and community-based adaptation strategies. Climate-related hazards were identified using traditional knowledge, skills and experiences. Historical timelines developed by the local people themselves revealed an increase in the frequency of drought incidences and shifting rainfall seasons, with unprecedented wildland fires devastating the study area. Community-based coping strategies as a response to the observed climate change impacts were also identified. However, the coping strategies practised by the traditional communities are mainly oriented towards survival, not continuous, motivated by crisis, reactive, often degraded the available resource base and are usually prompted by lack of alternatives. Therefore, local communities and traditional people in general need the support of the international community to continue their
role as traditional caretakers of marginal and fragile ecosystems, at the same time, build their capacities to adapt to the impacts of the current and future changes of global and local climates using more proactive approaches integrated into their indigenous knowledge base.

Mesfin Kassa Admassie’s ‘Farmers’ Perceptions of Climate Change and Local Adaptation Strategies in the Highlands of Ethiopia’ was intended to examine farmers’ perception of climate change/variability, household level impacts of climate change, and local adaptation strategies in the highlands of Menz Gera Midir district, North Shoa Zone, Amhara Regional State. Survey, focus group discussions and key informants were carried out in six Peasant Associations and 30-years meteorology data of climate variables was analysed. Ninety-nine per cent perceived that the amount of rainfall has decreased but the pattern and distribution varies over the decades. About 99.4% of the farmers indicated that temperature has increased over the past decades and the instrumental analysis confirmed the rise of mean minimum temperature by 0.25°C over three decades (1974-2004); three most important coping strategies were identified which include food consumption reduction, borrowing from relatives and engaging in daily labour.

Climate change impacts are one of the most serious challenges of the 21st century with multiple effects on human support systems particularly agricultural productive capacity and ecosystem functioning. In his ‘Assessment of Climate Change Impact on Agriculture and Land Use and Its Local Adaptation Responses: The Case of Humbo Woreda Southern Ethiopia’ Shemsedin Ahmed’s study was intended to examine changes in the pattern of climatic parameters, mainly rainfall and temperature, of the study area and to assess the resulting impacts on agricultural production and land-use land cover of the area as well as to examine and document local adaptation strategies. The change and variability in the climatic parameters was examined by analyzing rainfall and temperature data for the last three decades. The impact of climate change on agriculture and the local adaptation strategies were studied using a questionnaire survey. The impact of climate change on land use and land cover change was assessed using satellite images from three different time periods. The result of analysis of rainfall patterns in the study area showed a slight increasing trend for total
annual rainfall through time. However, there was a very high variability of annual, monthly and seasonal rainfall pattern in the study area. Average monthly temperatures in the study area also showed a slight decreasing trend through time. The results showed that the amount and distribution of annual and monthly rainfall caused a decline in agricultural yield. Also, this variability in the climatic patterns also affects the agro biodiversity of the study area. According to the study, the reduction of agricultural production and food insecurity forced the local farmers to highly depend on forest resource of the area. This in turn resulted in rapid land use and land cover change in the study area. The study revealed that farmers developed some local adaptation strategies to cope with problems such as on-farm, non-farm and off-farm livelihood diversifications, reducing the number of livestock per household, eating drought foods and utilizing social systems for helping each other during severe hazard conditions.

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THEME 1
African Indigenous Knowledge Systems (AIKS) in Climate Change Adaptation and Mitigation
Integrating Indigenous Knowledge Systems into Climate Change

Juliet Gwenzi
Department of Physics, University of Zimbabwe

Abstract
Issues dealing with climate change and climate variability have been dealt with and analysed across various disciplines, and decisions made based on climate science. Such decisions have applied mostly to communities within urban setups. In most cases the vulnerable people within rural communities have been left out of the process. Until now not much of indigenous knowledge systems have been established and made use of in climate change adaptation strategies. This chapter focuses on understanding available indigenous knowledge, the challenge of semantics across cultures, while paying particular attention to community experiences so as to give them salience. The flexibility with which humans communicate is developed into cultural schemas and these form indigenous ontologies that are then used to address the issue of semantic interoperability of indigenous knowledge across cultures. By making meaning of the contextualized indigenous knowledge, the chapter proposes ways of collecting and incorporating the finer details of community experiences into climate adaptation strategies. In this way the communities make contributions to development of tailor-made adaptation ways which are closer and much related to their own experiences. A conceptual framework is designed which integrates scientific methods to indigenous knowledge repositories as well as the impacts the importance of social responsibility from which the best mechanisms are provided for effective communication, dissemination of best adaptation options using a demand driven and bottom-up approach. To tie the systems together an
evaluation of introduced scientific strategies against indigenous strategies is done to demonstrate the role of indigenous knowledge in climate change adaptation strategies

**Keywords:** Climate change, Indigenous knowledge, variability, semantic interoperability, adaptation

**Introduction**
The view that climate change is the challenge of the moment is an undisputable fact. Climate change is one of the most pressing problems of our time hence governments seek to implement effective policies based on the best emerging science insights (Miah & Rashid 2009). It has posed untold suffering among people globally thereby necessitating the world to come together to find solutions and strategies to mitigate and adapt to the current and future climate changes. Through the United Nations Framework Convention for Climate Change (UNFCCC), protocols have been put in place to allow for coordinated scientific research on climate change. While much research has focused on science, resulting in formulations of mitigation and adaptation strategies, much remains to be done if these strategies are to be effectively adopted by the most vulnerable communities, more so in the rural areas (Nyong & Friel 2008). Such communities have local systems that they have relied on, which act as indicators to some phenomena occurring in a certain pattern such as rainfall. Not much of the systems which are a backbone to community resilience and development of coping strategies have been researched, let alone articulated with climate science.

Modern strategies designed for adaptation have focused on science-based research using systematic observations. The data shown in the climate change charts are what most scientists believe in today. We put all our trust in the numbers on these charts without really giving them meaning in terms of how they could be understood by the less educated. At the end of the day, the same numbers have to be translated into what it means to the most vulnerable communities on the face of the earth. Using the results based on the charts, decisions on adaptation strategies are often made and pushed down on the communities. The result of this approach is that indigenous knowledge has been neglected or marginalised yet this plays an important role in convincing the indigenous peoples and rural groups to use adaptation methods which are far removed from their natural world constructs and yet
tying with the landscape they live in. The imposition of scientific management regimes without the participation of local communities has prompted debate on whether the neglect of traditional knowledge violates human rights, civil rights and indigenous rights (Hardison 2009). Though research has focused on scientific methods, the fact remains that local populations, through their indigenous knowledge systems (IKS), have developed and implemented adaptation strategies which through the years have helped reduce their vulnerability to climate variability and change.

The current climate crisis offers a unique opportunity for indigenous people and their knowledge systems to be integrated into societal discourse about environmental change and stewardship. The participation of local people can no longer be neglected if sustainable strategies are to be designed. The qualitative, communal and place-based character of IKS may be the key to overcoming the current stalemate between scientists and climate sceptics. Making meaning of contextualized indigenous knowledge and incorporating the finer details of community experiences into climate change programs may lead to the change of demand-driven adaptation strategies which take a top-down approach. Such strategies are designed and implemented by the local people thus they are sustainable as they can be passed from generation to generation.

**Climate Change and IKS**

Climate change, according to the Inter-Governmental Panel on Climate Change (IPCC) is defined as any change in climate over time, whether due to natural variability or as a result of human activity. These changes are evident across the globe and have threatened household food security leaving many people very vulnerable and unable to cope with the now perennial climate shocks. To ensure food and economic security, farmers often experiment with existing practices to adapt them to changing conditions or to improve yields. In this regard farmers are ‘scientists’ in their own right as they are constantly experimenting and attempting to improve current practices (Bebbington 2008). Whilst scientific measurements have only helped scientific research, there is also the other side of the coin where the farmers continuously weigh climate options based on cognition and past experiences to make decisions. When farmers take steps towards using science-based climate information it is all about their attitudes based on their local knowledge and experiences.
Indigenous knowledge systems (IKS), according to Mapara and Nyota (2010) are a body of knowledge, or bodies of knowledge of the indigenous people of particular geographical areas on which they have survived for a very long time. The knowledge is unique to particular societies who have acquired it through years of experience, informal experiments and intimate understandings of the natural systems which are under stress from climate change together with socio-economic development. IKS as noted by Mateear et al. (2001) serves many functions for a community, household and individuals by functioning as a base of knowledge to help process information, promote efficient allocation of resources and aid in production method decisions. Semantics of IKS may vary depending on location and culture, however contextualising the meaning allows for the formulation of cultural schemas.

According to Hardison (2000), schemas are ‘networks of strongly connected cognitive elements that represent the generic concepts stored in memory’. D’Andrade (1995) expanded the concept and explained schemas as ‘flexible configurations, mirroring the regularities of experience, providing automatic completion of missing components, automatically generalizing from the past, but also continually in modification, continually adapting to reflect the current state of affairs’. The schemas form closely connected clusters of elements of IKS and the flexibility allows schemas to be used across different domains. The different domains (cultures) have different perspectives about particular a IKS, therefore the cultural schema, being flexible, should be able to accommodate diversity. It is important to realize that each culture has its own ways of legitimizing meaning and handling the semantics of its discourse (Gupta & Belnap 1997).

**Sustainable Adaptation Strategies**

According to IPCC, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences. Sustainable systems are therefore necessary to help communities adapt to climate change and extremes. Sustainable systems have the capacity to adapt to changing circumstances without undermining their long-term survival. They are resilient to shocks and are able to adapt to changes by reorganizing themselves (Folke et al. 2002). Within this context, vulnerable climate systems lack or are losing the ability to handle these
shocks. The use of IKS in such systems is of the utmost importance because they capture what ties the communities to their environment and any changes are driven by the communities themselves. This is contrary to those which do not involve local experiences because there are mixed feelings on whether the scientific forecasts have any use in local communities (Glantz 2003). The generation of these forecasts is based on statistical and simulation models that are often not understood by users, especially the poor and most vulnerable. These strategies, having failed to meet the needs of the users on their own, require other forms of local support that pay attention to what the local people understand and can identify with.

**Methodology**

This project seeks to develop an IKS framework which connects systems from multiple sources and link them to climate science for further application and development of sustainable adaptation strategies. Methods such as Participatory Rural Appraisals, focus groups and questionnaires are used to document IKS from different domains. These are connected to develop a cultural schema. Current exposure and coping mechanism are extracted, providing levels of vulnerability to climate shocks. An assessment of future exposure is modelled through modifications of current exposure using both IKS and climate science thereby providing a basis for future adaptive capacity. On one hand is the social science aspect formed from IKS and climate change while on the other is climate science alone. The aspect of vulnerability and adaptation science is formulated from which demand driven and sustainable adaptation strategies are developed as shown in Figure 1 below.

**IKS and Seasonal Climate Forecasts: A Case Study from Zimbabwe**

Whilst systematic observations have been used to forecast changes within the climate system, locals in Zimbabwe have their own indicators of a changing climate. Some of the experiences from local communities are:

- Drying of wetlands;
- Streams have now become seasonal streams; and
The regional die-out of some plants such as *tsambatsi* (*Lannea edulis*) and *maroro* (*Annona senegalensis*).  

**Figure 1:** Conceptual framework showing the integration of IKS and climate science in developing future adaptation strategies (a participatory approach)
In terms of forecasting rainfall for the summer season locals rely on their own indicators, a few which are given in Table 1.

<table>
<thead>
<tr>
<th>Indicator (IKS)</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Flowering of Chikuhunga (Barati) tree</td>
<td>Good rainfall season</td>
</tr>
<tr>
<td>Heavy Fruiting of Muchakata (Parinari curatelliofolia)</td>
<td>Good season</td>
</tr>
<tr>
<td>Strong and frequent whirlwinds</td>
<td>Good rainfall season</td>
</tr>
</tbody>
</table>

Table 1: IKS for seasonal forecasting

These indicators are not far removed from science and systematic documentation of all knowledge systems helps in the development of cultural schemas. Once a database of all IKS has been made, more research can be done on areas of convergence with science based on systematic observation of climate elements such as temperature, wind regimes and others.

Figure 2 gives a conceptual framework for integrating seasonal forecasts and IKS. Having a well-managed database with cultural schemas and every aspect captured as in Figure 1, data mining and modelling is done, from which the best strategies are developed. With historical records of seasonal forecasts in a database, documented IKS can be stored in the same database. The IKS is derived from the cultural schema as outlined in Figure 1 above. The wind regimes and seasonal temperatures also relate to global circulation models. These are also used in IKS, indicating areas of convergence. Indicators from plants and animals are also included in the database. Past seasonal climate forecasts can be modelled using the documented systems.

All combinations of indigenous knowledge from the schemas are tested and modelled using previous forecasts to come up with baseline scenarios for future modelling and improvement of the framework to make it scalable, expandable, implementable and sustainable. The framework needs to be scalable and expandable so as to be able to accommodate new IKS which may not have been documented and also to allow future modification to the database so new elements deemed important at a later time can be incorporated. The scenarios generated from modelling are disseminated to
the users who then choose their best options which are more related to their environment and the modifications thereof.

Figure 2: Modelling climate forecasts and Indigenous Knowledge for development of scenarios for climate adaptation strategies

Conclusion
Statistical and simulation modelling, the basis of climate science, rely on baseline studies based on historical data. Climate change reduces the reliability of such forecasting. Whilst there is a lot of emerging research on climate change, specific research addressing the role of IKS in climate change has been limited. Considering seasonal climate forecasts, there is a
level of convergence between climate science and social science-based forecasts which have helped communities to respond and cope with changes directly affecting them. The problem may be global, requiring a holistic approach, but the design and implementation of adaptation strategies require local sensibility through the use of indigenous constructs which tie the locals to the environment in which they live.

The chapter proposes a new approach which addresses cultural diversity while incorporating IKS into climate science in developing sustainable adaptation strategies. The process enables development of cultural schemas which are interoperable across domains. Indigenous knowledge can no longer be marginalised as the communities are responsible for the changes in their environment. Further studies are necessary to make a conceptual framework implementable in forecasting models in order to quantify signal strength of each of the indicators. There is need for systematic documentation which will lead to integration of IKS in seasonal rainfall forecasting which is quite promising as a first step in development of adaptation strategies more linked to local people.

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**Contributor information**
Juliet Gwenzi, Department of Physics, University of Zimbabwe, Harare
Tel: +263-774-350-828
E-mail: julievimbai@gmail.com
Interaction of Indigenous Knowledge Systems with Climate Change Adaptation and Mitigation in Uganda

Jacqueline Nassali
Department of Biology, Makerere University, Uganda

Abstract
Climate change (CC), the alteration of long-term weather patterns through human activity, is a problem currently affecting the world with dire consequences especially in developing countries. Africa, it is projected, will be among the most affected in the next twenty years (PFCC 2011). Literature has documented that farmers in Uganda seek information to anticipate the inter-annual variability in the timing and amount of precipitation, a matter of great importance to farmers since they rely on rain-fed agriculture for food supplies and income. Further, the effective use of indigenous knowledge (IK) by academia, development institutions and more importantly farmers could provide the solution to climate change adaptation and mitigation.

The increasing attention IK is receiving by academia and the development institutions have not yet led to unanimous perceptions of the concept of IK. In this light, this chapter seeks to demonstrate the importance of traditional/indigenous knowledge regarding CC adaptation and mitigation, outline some of the various IK systems used to protect natural resources and biodiversity in the past, present and possibly future, and to analyse effectiveness of the use of IK in Uganda. The Government of India in 2001 setup the Traditional Knowledge Digital Library (TKDL) as repository of 1200 formulations of various systems of Indian medicine (http://en.wikipedia.org). Similarly, South Africa has setup documentation and digital data systems for her traditional knowledge.

What is required is that Uganda too focus on programmes to re-invent
and organize traditional knowledge so it can set and meet some standards for the protection of the environment. A study needs to be undertaken of the possibility of evolving a system for protecting and utilising traditional knowledge. Programmes of research, documentation and digital data systems for Uganda’s traditional knowledge should be developed as has been done in India and South Africa.

**Keywords:** Indigenous Knowledge Systems, Climate Change Adaptation and Mitigation, Uganda

**Introduction**

Uganda is a landlocked country covering an area of 241039 square kilometers of which open water and swamps constitute 43941 square kilometers, 18.2% of the total area. The average altitude is 1200m above sea level, with most of the country falling within this moderate range. The lowest altitude is 620m (within the Albert Nile river basin) and the highest altitude (Mt. Rwenzori Peak) is at 5110m above sea level. The climate is equatorial, with moderate humid and hot climatic conditions throughout the year. Uganda has two rainfall seasons annually, which merge into one long rainy season as you move northwards from the equator. The first is from March to June, and the second from August to November. Uganda has a population of 34612250 (2011 est.) and an average GDP per capita of US$466 (2010 est.).

Climate change is a serious risk to poverty reduction in Uganda and threatens to frustrate poverty eradication and the Millennium Development Goal programmes. It could undo decades of development efforts through destruction of infrastructure and property and loss of life (Huber & Gulledge 2011).

According to Phillip Gwage of the Climate Change Unit in Kampala, if the temperatures rose by more than 2 degrees centigrade, production of coffee, Uganda’s main cash crop, would decline by 85%. Only a few parts of the mountainous areas like Mbale, the Rwenzori and the former Kigezi districts would retain suitable weather conditions for producing coffee (FAO 2009). Most of the predicted social and economic costs associated with climate change will result from shifts in the frequency and severity of extreme droughts, floods and storms (Huber & Gulledge 2011). Figure 1 below shows the impact of temperature rise on Robusta coffee.
According to William (1995), indigenous is termed as that which originates or occurs naturally in a particular place, while knowledge is defined as facts, information and skills acquired by a person through experience or education. Therefore, indigenous knowledge can be defined as facts, information and skills originating or occurring naturally in a particular place acquired by a person through experience or education. In Uganda indigenous knowledge occurs in various forms and systems. The importance of indigenous knowledge for biodiversity conservation in the country is to protect:

(i) Particular biological communities, for example plant species and vulnerable wetlands;
(ii) Birds, animals and particular fodder tree species;
(iii) Organisms at vulnerable stages of their lifecycle; and
(iv) Periodic harvesting, which is carried out as a group activity to monitor populations and harvesting levels effectively (Rugadya 2006).
Clans in Buganda – Empologoma

Uganda has a rich and diverse stock of indigenous knowledge in all human sectors, including medicine, music, food production, folklore, dance, apprenticeship and craftsmanship. At present Uganda has six major kingdoms, Buganda, Bunyoro, Busoga, Ankole, Bukonjo, Toro, Teso and Alur chiefdoms. The kingdoms and chiefdoms traditionally had political and administrative powers which led to collision with colonial and post-colonial central governments hence their abolition in 1967. Currently, these institutions mainly symbolize history and are mandated to promote people’s cultural heritage. Despite the weakness and limitations like lack of funding and the lure of political expediency, there are some emerging programmes like Bulungi Bwansi, Senga and Ekisakate that build on indigenous knowledge in Buganda kingdom (www.engabuzatooro.or.ug).

Some traditionalists and development workers have organized themselves into regional and national associations to safeguard and promote indigenous knowledge in Uganda. These include, among others, the traditional herbalists’ organizations, Buganda N’eddagala lyayo, Uganda Development Theatre Association (UDTA), Uganda Community Museums Association (UCMA), and Society for Advancement of Ugandan Languages (SAUL) (www.engabuzatooro.or.ug). In addition, according to the Cross Cultural Foundation of Uganda (CCFU), 23 organizations and projects are using indigenous knowledge in development interventions in various socio-economic projects, for example Engabu Za Tooro in Western Uganda which creatively uses an indigenous tradition of an ancient Tooro heroine – Koogere to promote women’s participation in development (CCFU 2007).
The five original Baganda clans referred to as ‘Banansangwa’ meaning ‘the indigenous clans’ are: Ffumbe (Civet cat), Olugave (Pangolin), Nηonge (Otter), Njaza (Bohor Reedbuck) and Nyonyi (Egret) for a Muganda to eat his or her (totem) clan whether its food, fresh meat, vegetables, fish or fruits hence biodiversity protection. To date there are fifty Baganda clans (Apter 1995).

Clans in Buganda:

Nyonyi
Riddles, myths, legends and proverbs tell the origin and history of the Baganda, as well as the workings of the everyday world. These are some examples of the proverbs: ‘engero’: ‘Ekuba omunaku tekya’, which can be translated as ‘for the poor when it rains it does not stop’; ‘Akutwala ekiro omusiima bukedde’, meaning ‘he who leads you at night, you thank in the morning’; ‘Omumpi wakoma wakwata’, translated as ‘the short man touches where he can reach’, ‘Ndyebaza ndya tagunjulamunafu’, meaning that ‘I will thank you when I have eaten, does not encourage the lazy or weak’; ‘Mazzi masabe tegamala nyonta’, translated as ‘water you beg for does not quench your thirst’; and, ‘Liinda kigweyo afumita mukira’, meaning ‘wait for it to fully come out and you spear the tail’. The meanings of these proverbs are highly nuanced and are applied in context to particular situations to achieve desired results, for example educating, comforting or encouraging people depending on their circumstances (Cox 2000).
Clans in Buganda: Njovu

The formal religions in Uganda consist of almost 90% Christians and a sprinkling of Islam supplemented with ancient superstition. Many Ugandans still turn to witchdoctors and herbal medicines as a system of healthcare. In Uganda science takes its place alongside superstitions as a competing method of understanding the world. The traditional Ugandan cultural institutions that existed before Christian missionaries came to Africa treated the environment with a great deal of respect. It is on the basis of this consideration that IK is regarded in Uganda as vital to the implementation of natural resource management policies including forest protection policies through passing information from one generation to the next. For instance, the Mpanga Forest Reserve in Mpigi district, which used to be a burial ground for some heads of cultural institutions, clearly shows that cultural institutions respect natural resource management (Spear 1998). However, when conditions change, knowledge production is bound to change. Trust in traditional set-ups and norms are eroded, thus stressing capacities to mitigate and adapt to climate change. Conversely, indigenous communities will need to adjust their livelihood strategies to cope with an altered environment.
Climate Change in Uganda

Climate change adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the climate-related risks in the local areas (Nyong & Friel 2008). CC mitigation strategies are procedures or activities that help prevent or minimize the process of climate change. Given the uncertainties and risks related to CC, it makes sense to take lessons from actual events about our current vulnerabilities and the risks to society caused by unabated greenhouse gas (GHG) emissions that drive extreme weather risks ever higher as time passes. Climate science can provide risk-based information that decision makers can use to understand how risk is changing so they can prioritize and value investments in mitigation and adaptation (Huber & Gulledge 2011). Climate variability and its impacts have led communities to develop coping strategies for climate-related disasters such as droughts, floods and storms (that is to say, lightning, wind, rain, thunder and dust). However, the frequency of these events in the past was low and therefore coping mechanisms have not been documented, developed or popularized but have been passed from generation to generation through traditional and cultural practices (MWE 2007).

Uganda endorsed the United Nations Framework Convention on Climate Change (UNFCCC) on June 13 1992 and thus committed itself to reduce GHG emissions and consider a shared vision on CC, and actions on adaptation, mitigation, finance, capacity building and technology development and transfer (PFCC 2011). However, to date there has been minimal response and results. Efforts by regional organizations like East African Community (EAC), Common Market for Eastern and Southern Africa (COMESA), Southern African Development Community (SADC), New Partnership for Africa’s Development (NEPAD), Economic Community of West African States (ECOWAS), African Union (AU), Intergovernmental Authority on Development (IGAD), African Ministerial Conference on the Environment (AMCEN), academia as well as the Least Developed Countries and Africa Group under the UNFCCC process have come up with several interventions including the possibility of the use of indigenous / traditional knowledge to reduce the risk related to climate change. Uganda’s main concern is drought followed by storms and landslides, which are confined to highland ecosystems.

Kendall (1999) indicates that extreme climate variability such as storms, floods and droughts often have far reaching environmental, health and socio-economic impacts in the Lake Victoria Basin including Uganda.
He suggests that to counter this trend, there is need to have in place efficient and realistic climate risk reduction strategies, including effective early warning systems to enhance planning efforts and reduce negative impacts, take full advantage of positive impacts, and help in mitigation and adaptation to climate change.

In the context of sustainability of involving IKS and African youth in climate change adaptation and mitigation, community-based adaptation strategies that empower local communities to take action should be formulated. From a developmental point of view, wider access to indigenous knowledge and information will help reduce climate risks and inequalities within communities by opening up opportunities for vulnerable members (women and youth) to benefit from integrated climate knowledge and strategies for sustainable use, management and conservation of biodiversity.

Effectiveness of the Use of Indigenous Knowledge Systems as Climate Change Adaptation and Mitigation Strategies in Uganda

The International Indigenous Peoples Forum on Climate Change (IIPFCC) held an SBI In-session workshop titled ‘Indigenous People’s Participation at UNFCCC’ on June 8 2011 to further develop ways to enhance the engagement of observer organizations. It was found that indigenous peoples are among those most impacted by climate change and have traditional and local knowledge that needs to be fully recognised and respected in global, national and sub-national efforts to respond to CC (UNFCCC, 2011).

Following Decision 16 COP7 concerning traditional knowledge, the Conference of Parties stated that it,

- **Encourages** parties to develop initiatives on traditional knowledge in collaboration with other institutions and organizations;
- **Invites** parties to protect, promote and use traditional knowledge, involving local experts and local communities; and
- **Further invites** parties to foster integration of traditional and modern knowledge in combating desertification.

Various communities in Uganda have been able to live in harmony with their environments for generations due to indigenous knowledge
systems. These systems are important tools in environment conservation and natural disaster management. Traditions, customs, beliefs and cultural rights play an important role in environmental conservation and biodiversity. In Uganda communities maintain shrines and protect forests that are used as places of worship and sources of herbal medicine (UNEP 2008).

Ugandan communities have a vast fund of knowledge on prediction and early warning systems, time-tested coping mechanisms, food production and storage techniques, and extensive plant-based medicines. Indicators of droughts, floods and storms include observation of the behaviour of birds, animals, reptiles, amphibians and insects and by observing vegetation, trees, wind, temperatures and celestial bodies.

Herbal medicine is a time-honoured coping strategy practiced by many communities to treat common ailments e.g. malaria, diarrhoea, wounds, worms, skin diseases, eye infections, coughs and colds. There are increasing reports of malaria parasites showing resistance to western malaria therapy. The increasing costs of malaria drugs, particularly new drugs, coupled with resistance to older malaria drugs has led people to turn to herbal medicines to cope with malaria epidemics. Although some herbs have been domesticated, the majority grow wild and are now endangered by unsustainable use. There is need to develop guidelines on their use. In terms of animal health in Kabira sub-country, Rakai district, East Coast Fever in cows is treated with the roots and leaves of herbs (Kamoga 2010).

Regarding farming technologies, the Bakiga people in Kabale highlands developed a system of growing crops on hillsides thus controlling soil erosion and improving soil moisture and fertility. Likewise the Uganda wildlife Education Centre (UWEC) has adopted Buganda’s clan and totem system to supplement the conservation effort (Daily Monitor 2010).

Water harvesting is a commonly practiced coping strategy. With the frequent droughts and water scarcity, communities have been harvesting water from various sources, e.g. ground water, rooftop water and the stemming of runoffs. Various approaches are used to harvest and clean the water e.g. the use of Moringa seeds in Nyabushozi and communal dams. Figure 2 shows the construction of a community underground water reservoir to militate against climate change. The harvested water is used for household use, livestock, crops, construction and brick making. In agriculture, stem runoff is used in drip irrigation of crop
plants notably vanilla, bananas and vegetables. Water harvested from the ground run-off is stored in open and underground reservoirs and used in various ways including soil conservation.

Indigenous knowledge approaches to environmental conservation include shifting cultivation, mixed cropping and agro forestry. These methods of land-use management promote higher yields while at the same time conserving the environment, for example, mixed cropping of maize with beans promotes efficient labour utilization. It also lessens the risk of total crop failure since chances are that if one crop succumbed to environmental stress, the other would survive. Mixed cropping stabilizes yields, preserves soil and makes it possible to harvest different crops at the same time. Other advantages are reduction in susceptibility to crop pests and diseases (UNEP 2008).

Food preservation is another time-honoured technology and coping strategy practised by many communities to ensure food security. Different techniques are used, for example sun drying, use of herbal plants and ashes to store food, use of honey to preserve meat and smoking. This indigenous knowledge is underutilised and not documented. Therefore, there is a strong need to promote these strategies.

Frequent occurrence of droughts and heavy rains have caused communities to devise a variety of measures such as growing drought-resistant crops and gathering wild fruit and vegetables that have enabled them to survive with little or no support from the outside world. Some communities in Mbarara district believe that special plants such as the Mutete and Lwanyi prevent thunderstorms, and are planted near homesteads. Similarly, not eating animals killed by lightning is believed to prevent the
recurrence of thunderstorms. It is, however, doubtful whether these coping strategies are not based on superstition (Masika 2002).

Musambwa Islands are some of the smallest islands located in Lake Victoria in Rakai district. Despite their size, they support large populations of congregatory breeding birds of the African race like the Grey Headed Gull (in picture), Greater Cormorant, Little Egret and the Long-tailed Cormorant among others. Due to the global importance of the birds, the islands have been recognized as an Important Bird Area. The islands are known to be the largest breeding site for the African species of the Grey Headed Gulls in Africa. The transient behaviour of local fishermen coupled with inadequate environmental awareness has led to considerable breakdown of the traditional pro-conservation norms and practices such as sustainable harvesting of gull eggs. Traditionally, the practice was to harvest one egg from the nest before the incubation period which ensured a steady supply to the then small population on the island as well as enabling the successful breeding of birds. However, with increased influx of people of different origins, this practice has been greatly compromised leading to reduced breeding success of bird species. The eggs are increasingly attracting higher commercial value on the mainland, and this has affected the bird populations on the islands.

Further, local people both on the islands and at the fish landing sites on the shores of the lake require wood for fuel and shelter construction yet there is less wood and vegetation resources on the islands since the islands are very rocky. Despite this, the limited wood and vegetation resources on the islands have become the only source of materials for shelter construction and fish smoking for the fishermen. This coupled with inadequate technical knowledge of community members in habitat management and restoration has resulted in vegetation degradation thus
leading to loss of cover for breeding birds, increased predation and post-harvest losses. In addition to the Musambwa Island by-law that was promulgated in an attempt to address these issues, there is a need to develop guidelines to protect vegetation and bird species. The intellectual property rights components covered by the Ugandan legal system include patent, copyrights, trademarks, designs, geographical indicators, integrated circuits and plant variety (Davidson 2000).

Below are the government policies that support development of traditional knowledge:

- Restoration of Cultural Institutions;
- Uganda National Policy on Culture;
- Policy on Use of Vernacular Language at primary level of education;
- Draft Policy on Traditional and Complementary Medicine; and
- Policy allowing private investment in traditional knowledge and the cultural sector.

Unfortunately, the above policies are either ignored and proponents disempowered to take on their natural and constitutional roles or there are challenges in implementation, owing largely to a lack of budgetary support. There is lack of political will as indicated by the fact that Uganda does not have a national council on arts and culture. This is compounded by the fact that Uganda has only one national museum and one national theatre, which were built in the colonial era. Uganda has not ratified conventions like the 2005 UNESCO Convention on Protection and Promotion of Diversity of Cultural Expression (Akubu 2005).

**Conclusion**
This study argued that Uganda has great potential to cope with droughts, floods and storms with minimum support from the outside world using indigenous knowledge as a prioritized strategy for climate change adaptation and mitigation. The Government of Uganda should ensure budgetary support and political will, and focus on programmes to re-invent and organize traditional knowledge so that it can meet some standards for protection of the environment. Further studies should be undertaken on the possibilities of evolving a system for protecting traditional knowledge. Programmes of
research, documentation and digital data systems for Uganda’s traditional knowledge should be developed as has been done in India and South Africa.

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**Contributor information**
Jacqueline Nassali, Dept of Biology, Makerere University, P.O. Box 7062 Kampala, Uganda
Tel: +256-782-50-7456
E-mail: Jaqlins@yahoo.co.uk
Cultural Values and African Indigenous Knowledge Systems in Climate Change Adaptation

Hassan O. Kaya
University of Kwazulu-Natal

Yonah N. Seleti
Indigenous Knowledge Systems Office
Department of Science and Technology (South Africa)

Abstract
This chapter is based on a study that examined cultural values and African indigenous knowledge systems in climate change adaptation and interpretation. It is argued that western scientific explanations of climatic change have mainly concentrated on anthropogenic, greenhouse gas emissions while indigenous African knowledge-based interpretations of observed climate changes are often much more varied and encompassing. It emerges that in some local communities the media and its coverage of climate change dominate local people’s understanding. These local, personal observations and experiences evoke deeply felt emotions as familiar signs of seasonal changes become decoupled and invalidated. This wealth of indigenous knowledge based on many years of observing and working with the natural environment is orally transmitted. It needs to be documented in order to contribute to the global pool of knowledge and climate change policy development.

Keywords: African Indigenous Knowledge Systems, Climate change adaptation and interpretation
Introduction
In his discussion of the relationship between culture and climate change, Van den Pol (2010) states that climate change is no longer a mere scientific curiosity or just one of many environmental concerns. It is an overriding environmental issue of our time and the single greatest challenge facing environmental regulators. It does not only influence our economies, but also our health, safety, food production, security and other livelihood dimensions. It might have different effects on different countries and cultures, but climate change is a problem which influences the whole world. Therefore, as a global problem it requires global solutions.

In his contribution to the debate, McCright (2003) emphasizes the necessity of cross-cultural communication in the search for sustainable solutions to the challenges of climate change affecting different countries. This is due to the acknowledgement that people from various cultures and countries live in different environments, with different backgrounds and experiences. These cultural differences influence both the content of their local knowledge as well as the way it is being shared and expressed. According to the Intergovernmental Panel on Climate Change (IPCC 2001) climate change refers to,

- a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forces or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Baldwin (2004) defines culture as the beliefs, behaviours, objects, and other characteristics common to the members of a particular group or society. Through culture, people and groups define themselves, conform to society’s shared values and contribute to society. Thus, culture includes many societal aspects: language, customs, values, norms, mores, rules, tools, technologies, products, organizations and institutions. Relatively, Anderson (2004) states that African indigenous communities, like other indigenous local peoples all over the world, have developed unique and complex systems of culture and knowledge of their local communities and environments based on countless centuries of observation, innovation, experimentation, practice and monitoring. Balslev (1996) notes that they have accumulated a wealth of
knowledge about these assets – on the growth and lifecycles of plants, the habits of animals, and the responses of these species to particular environmental conditions, including seasonal changes, heavy rainfall, storms, floods, unusually high or low temperatures, fire, drought and disease outbreaks.

Therefore, Indigenous Knowledge (IK) is that knowledge unique to a given culture that has been acquired through accumulation of years of experiences by local people and is passed on from generation to generation. In addition, IK is a precious local and national resource that can facilitate the process of disaster prevention, preparedness and response in cost-effective participatory and sustainable ways. Hence a blend of approaches and methods from science and technology and from traditional knowledge opens avenues towards better disaster prevention, preparedness, response and mitigation (Wolff 2003).

Methodology
This was a survey of cultural values and African indigenous knowledge systems (IKS) in climate change adaptation and interpretation. The study was based on the examination of secondary sources. According to Black (1996) secondary data refers to information gathered by someone other than the researcher conducting the current study. Such data can be internal or external to the organization and accessed through the internet or perusal of recorded or published information. The study used relevant sources of secondary data, including books, periodicals, and government and non-governmental publications related to the research problem, among others. Taking into consideration the comprehensive nature of this study, the researchers consulted secondary data because it was available, appropriate and adequate to draw conclusions from. It was far cheaper in this case to collect secondary data than to obtain primary data as the time involved in searching secondary sources was much less than that needed to complete primary data collection procedures. The following section presents and discusses the findings.

African Indigenous Knowledge on Weather Predictions
McCarty (2002) reveals that research in various parts of Africa has demonstrated a rich knowledge of weather prediction among local communi-
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This knowledge has for centuries enabled people to cope with changes in the weather patterns such as storm routes and wind patterns, all allowed them to design disaster management strategies and mechanisms long in advance by constructing specific types of shelter, wind break structures, walls and homestead fences appropriately. Similarly, knowledge of local rain corridors enables them to prepare for storms. Muya (2006) shows that among the Wasambaa in Tanzania the knowledge of the colour of clouds that may carry hailstones enabled people to run for cover. The Wagogo who live in the dry areas of central Tanzania knew that prolonged drought was followed by storm and thunder during the first few rains. This enabled people to expect and prepare for a disaster. The Batswana and other ethnic groups of Southern Africa knew that floods could be predicted from the height of birds’ nests near rivers. Moth numbers were used to predict drought conditions. The position of the sun and the cry of a specific bird on trees near rivers assisted to predict the onset of the rainy season (Brown 2004).

Moore (2010) provides examples of African rainmakers who are slowly gaining national and international recognition. The scientific world has begun embracing them as partners in unravelling the never-ending mysteries of Mother Nature. In fact, modern climate experts in Africa are looking up to African indigenous knowledge as a probable salvation to the current devastating effects of climate change. Mojon (2011) in the Mail and Guardian of 20 September 2011 provides the following information using the case of Western Kenya on the increasing importance of African rainmakers.

Long vilified as sorcerers, Kenya’s Nganyi rainmakers, with their meteorological equipment consisting of trees, pots and herbs, are being enlisted to mitigate the effects of climate change. Mojon reports the case of Alexander Okonda, an African rainmaker in western Kenya, near Maseno, kneeling in the dark shade of a small coppice, blowing through a reed into a pot embedded in a tree hollow that contains a secret mixture of sacred water and herbs. He is a member of the Nganyi community, a clan of traditional rainmakers that for centuries has made its living disseminating precious forecasts to local farmers. Alexander says and explains, after completing his ritual:

This contains so much information. It is something I feel from my
head right down to my toes .... This skill is in the family, it runs in our blood. When I was a six-year-old boy, I could already feel so many things.

Interviews with these indigenous knowledge holders and practitioners revealed that the croak of the frog, the movement of the termites, the leafing of certain trees all carry information, the interpretation of which the Nganyi have transformed into a ritual art hovering between legend and science. The Nganyi’s fame was sealed when Okonda’s great-grandfather, ‘the greatest rainmaker in the family’, was detained in the 1910s by the British colonial authorities who believed he was responsible for poor rainfall.

The great-grandfather had 30 wives and was buried in a sitting position with a rainmaker’s pot on his head in a site near the western town of Kisumu which is now one of the main natural shrines used by his descendants to concoct their brews and divine forecasts. Modernization has slowly eroded the community’s aura but the Nganyi have recently been offered a way of reviving their traditions through a project aimed at using indigenous knowledge in disaster prevention. This programme is funded by Britain and Canada. It brings the Kenya Meteorology Department (KMD) and traditional rainmakers together to produce more accurate forecasts and disseminate them to a wider number of people.

In her discussion of rainmaking and climate change in Tanzania, Oestigaard (2011) states that in Tanzania rainmaking has been an intrinsic part of culture and religion. The rainmaker is responsible for the wealth and health of his/her people by controlling and providing the life-giving waters. Thus, the rainmaker tried to control and manipulate nature by rituals where the forefathers and the deceased provided rain through the chieftain or the king as a medium. The chieftain or king’s divinity is defined by his power to control disasters, which included the fertility of the fields, the health and wealth of humans and animals, epidemics, plagues, and safety from attacks by wild beasts, to name a few. If the chieftain or king failed to provide the life-giving waters, wealth and health to his people, he could be killed because he threatened the safety of the society. Agricultural practices were thus deeply rooted in culture and religion thereby linking the ancestors to the structure and governance of society. These beliefs co-exist in Christianity where droughts or failure of the annual rains are seen as a penalty by God.
due to people’s disobedience and sinful behaviour. These traditional belief systems are under pressure due to modernity and globalization.

Therefore, in order to understand changing agricultural practices the project studied the relation between traditional rainmaking and agricultural practices in the face of modernity and globalization. To this end, a dual approach was adopted. The first approach explored how changes to or resilience in the traditional culture and religion with regards to rainmaking affects the actual agricultural practices. The other approach looks at how the introduction of new agricultural activities and crops, higher stress and pressure on land and water resources, growing population, shortage of food, erratic rainfall patterns and climate change all influence the actual ritual practices and religious beliefs with cultural consequences in society?

The area of investigation was in the Mwanza region in northern Tanzania by the shores of Lake Victoria. Mwanza is the second largest town in Tanzania. Eighty-five percent of the population in the Mwanza region practice smallholder agriculture. In this region, rivers flow into Lake Victoria which also enabled a comparison of how traditions and rituals with regards to different bodies of water such as rain, rivers and the lake may enable a variety of changing strategies and agricultural practices in relation to globalization and climate change.

The Use of African Indigenous Knowledge Systems as Climate Change Adaptation Strategies
Bewes (2002) reiterates that African local communities and other indigenous communities around the world may suffer most from climate change due to a combination of high dependence on ecosystems, occupation of marginal lands, social pressure and lack of political representation. However, due to their long dependence on nature they have developed strategies to cope with climate change and extreme natural events which still have as much relevance today as they did hundreds of years ago.

For instance, the Rufiji river valley area in Tanzania has been for many years prone to frequent floods. Local people in the area who depend on agriculture and the waters of the Rufiji river built houses on stilts so that floodwaters could pass underneath the floor of the house without damaging it. Brush (1997) elaborates that stilt houses or pile dwellings or palafitte are houses raised on piles over the surface of the soil or a body of water. Stilt
houses are built primarily as a protection against flooding but also serve to keep out vermin. The shady space under the house can be used for work or storage. This type of indigenous knowledge and technology is now being promoted across the world by modern architects. He illustrates some of the advantages of this form of indigenous architecture: (i) help to protect houses from floods as electric cables, wiring and plug sockets are higher above the water level. In tropical areas such as the Rufiji river valley in Tanzania which is prone to flooding, this structure of a dwelling above the level of the flood plain (i) helps to keep families safe; and (ii) living in a raised house lowers the risk of mosquito bites and the associated risk of malaria.

**Cultural and Spiritual Interpretation of Climate Change**

Folke (1998) argues that while scientific explanations of climatic changes have mainly concentrated on anthropogenic, greenhouse gas emissions, indigenous knowledge-based interpretations of observed climate changes in Africa and elsewhere are often much more varied and encompassing. He elaborates that whether scientific models are incorporated into local community-based interpretations and explanations or not depends on the status and accessibility of science within a culture and on the influence of the media. In some places, the media and its coverage of climate change issues dominate local people’s understanding of climate change. Nonetheless, local people’s own observations are local and tangible. Henderson-Sellers (2002) observed in a Tswana village in South Africa that seldom do the media report on local climate changes that impact the timing and outcome of agricultural and other community activities. These local personal observations and experiences evoke deeply felt emotions, as familiar signs of seasonal changes become decoupled and indigenous or traditional knowledge of the weather becomes invalidated.

For example, in November of 2009, a very special meeting took place within the Tshidzivhe community of Venda, in the Limpopo province of South Africa. The meeting was to carry out an exercise in community participatory mapping, and it was to mark a turning point for the community and all those involved. Chief of Vhutanda said: ‘our countryside is being destroyed, and our forests have disappeared … for me the forests are my life. If you cut them down, you wound my own heart’.
Venda is home to the traditional indigenous vhaVenda, known as the Rainmakers. It is one of the regions of South Africa where such communities practice their traditional ways of life. The vhaVenda people are a matriarchal society, where the ecological knowledge which guides the governance of the community is held by women, known as makhadzis. Many of the makhadzis are also custodians of sacred natural sites and are responsible for the associated community practices and rituals that keep order in the community and the ecosystem.

Furthermore, the impact of colonization and industrialization has fragmented local communities, changed power relations and destroyed the rich biodiversity and forests of the extraordinary Soutpansberg Mountains in the northeast of South Africa. Industrial plantations, mining and tourism are some of the major forces contributing to environmental degradation in the area.

The makhadzis are deeply pained by the destruction of their traditional territory especially the sacred sites. The makhadzis began to sketch the relationship between the sacred sites, showing how these sites are critical places within the ecosystem – natural springs, forest, wetlands, river basins and waterfalls – which maintain the health and resilience of their ancestral territory. With support from the African Biodiversity Network and Gaia, a community exercise in eco-cultural mapping was then carried out in November 2009. More than 70 vhaVenda people took part, mostly from Tshidzivhe community, guided by trainers in eco-cultural mapping from Colombia and accompanied by indigenous leaders from the Colombian Amazon and the Russian Republic of Altai. Joyce, a makhadzhi elder had this to say:

When I look at the map we are drawing I feel I could cry. Our territory has been badly hurt …. I cry for the coming generations. How are they going to live when this country is destroyed?

Women, men and youth in the community spent six days mapping. It was a time for deep reflection as the elders shared their knowledge of the territory, the sacred sites, the traditional practices and rituals, many of which are on the verge of being lost.

As part of the mapping process the community knowledge-holders were involved in remembering the territory, the sites of ecological and
cultural importance, and the role of ritual. The first map showed the ancestral order of the territory, reflected how things were when the community was living traditionally. This was still in the living memory of the elders – when the territory was teaming with wild animals, forests and had abundant rain. The second map was of the present. This, the makhadzis said, is the map of disorder – where the forests are destroyed, there are no more wild animals, rivers and lakes are drying, the rainfall has dropped radically and the traditional crops have almost disappeared.

The final map is of the future – the vision of how the communities wish to regenerate the territory and rebuild their communities. They have already begun. Elders are teaching in schools to revive knowledge of traditional seed diversity and the communities are working with Mupo Foundation, a South African NGO, to restore and strengthen their biocultural knowledge and practices.

As the different maps were completed the makhadzis sang and danced in celebration! They had unearthed a new capacity to express and interpret their traditional ecological knowledge so that the community can hold a collective vision. Based on this experience they are planning to develop more detailed maps around each sacred site. These will be used to negotiate with the government to recognize and protect each site and the connection between them. In the face of climate change, the health and vitality of ecosystems are critical. This is the basis of ecological and community resilience.

Years of colonisation and the encroachment of the western world on traditional cultures have meant that the makhadzis became increasingly marginalised and silenced. Their traditional roles as advisers to the chiefs and as keepers of the indigenous seeds have slowly been undermined. But now, with support from the Mupo Foundation the makhadzis are rallying to protect Venda’s network of sacred forests and to set an important legal precedent for South Africa’s natural and cultural heritage.

In 2009, the makhadzis were joined by the elderly men and chiefs of the community to form Dzomo la Mupo (meaning Voice of the Earth), a small community-based organisation, ‘to protect nature in all her forms, and especially indigenous forests … [and] to protect and preserve sacred sites in Venda’. A Rainmaker elder at work says:
There exists a small network of bountiful forests in Venda, the source of springs that feed into the Luvuvhu River. The river catchment provides water for the surrounding land and communities, and the forests are revered as sacred; they are places where the ancestors reside and where peace must be maintained. It is the responsibility of the *makhadzis*, as the traditional custodians of these sacred forests, to ensure that they are safeguarded and respected.

On the basis of the above practical community experiences, western scientific causal explanations of climate change may be seen as abstract and removed from social and cultural reality. This is due to the fact that they tend to make people feel powerless and/or not responsible for combating climate changes, despite their own vivid experiences of climate change impacts in their own environment. Henderson-Sellers (2002) provides the example of farmers in western Austria, who had many detailed observations of climate changes, ranging from increased wind-felled trees, increased drought, and decreased snow cover, but whose information on climate change causes was largely drawn from the mass media so people did not see themselves as connected to the causes or their solutions as portrayed in the media.

In contrast, where mass media played a limited role, community interpretations were more closely dependent on people’s own observations and the local cultural framework. As shown by the Venda experiences, many local interpretations contained strong ethical and spiritual elements, often framed in terms of a cosmological or spiritual balance, which has been upset. These interpretations are not created *ad hoc* to explain present-day climate changes, but in many instances have their roots in traditional ways and cultural experiences of interpreting climatic and weather phenomena as signs of something more than mere biophysical processes.

Proctor (1998) demonstrates that in any part of the world and within the context of different belief systems local people have traditionally interpreted adverse weather conditions as well as more catastrophic events as punishments for human wrongdoings. Examples are thunderstorms and hail, which express the wrath of local deities in the Congo forests of Central Africa, and volcanic eruptions in British Columbia, which were interpreted as retributions for cruelty. The adverse climatic conditions or catastrophic events are thought to be caused by the breach of taboos, such as hunting at certain times or places, picking specific plants, or eating certain foods.
General moves against human cruelty, selfishness, greed or lack of spirituality, if transgressed, are also thought to precipitate catastrophe. These moral or spiritual explanations of climate change contrast with scientific explanations. However, other traditional people integrate scientific and local explanations. For example, there is a view among the Wasambaa and Wazigua in Tanzania that climate change is caused by people’s greed and selfishness in over-consumption that leads to environmental degradation of land and water. Local views of climate changes are characteristically interwoven with other environmental and societal problems including outbreak of diseases and frequent deaths in the local and neighbouring communities.

In general, local communities’ interpretations of climate change may help people better make sense of observed climate changes, but do not necessarily empower them to act. This is especially the case where climate change threatens landscape features of spiritual value, or where the culprits of climate change are perceived to be outsiders. These ‘others’ can be other parts of society, the state, companies or western cultures, which are generally seen as being outside the sphere of local influence.

McCright (2003) when discussing interacting factors affecting perception, interpretation and adaptation, states that local peoples’ experiences and interpretations, as well as scientific research, indicate that climate change is seldom isolated, but interacts with other environmental and social factors. Interactions affect peoples’ perceptions, interpretation and adaptations to climate change tremendously. Many climate change factors are interconnected. Peoples’ interpretation of climate change is affected by both media and cosmology. Peoples’ perception of climate change may be influenced by normal inter-annual variations such as El Niño-related droughts in the Congo forests and multi-year rain-drought-patterns in Southern Africa. Such irregular patterns make it harder to detect any long-term climate change. Difficulties in detection of climate changes will influence people’s ability to adapt. However, people who normally respond to recurring climatic variation (e.g. droughts or floods) may be better prepared to adapt to long-term climatic changes. Klein et al. (2005) provide the example of local communities in Mozambique which have developed various local strategies of coping and mitigating climate changes due to frequent flood experiences.
They may adjust their existing strategies for coping with short-term crises to create long-term adaptive strategies. Other factors that may influence adaptation of human societies include insurance schemes, government benefit schemes, policies, social relationships with other groups, access to information, NGO projects, land rights, and access to resources and ecosystems. According to Bewes (2002), insurance and government help may provide crucial assistance to disaster-struck people; it may also remove the incentive for adaptation and preventative measures. He shows examples of cases in diverse settings including the desert peoples of the Kalahari. Government policies and development initiatives (whether government or NGO) may promote or hinder adaptation, depending on whether these only aim at short-term economic development or also take into account impending climate changes (Brown 2003).

McCarty (2002) shows that there are ample examples of projects and programmes that have promoted agricultural or economic enterprises, which will be unsustainable under changing climatic conditions. Muya (2006) provides the example of small-scale rice farmers in the Mkomazi Valley in Tanzania, where, with decreasing access to water, dependence on irrigated agriculture has increased the farmers’ vulnerability to climate change. Whereas Samson (2004) shows cases in Kenya where NGOs and state agencies help to disseminate information and promote crops and management methods suitable under changed climatic conditions, agricultural assistance supports communities’ own efforts at climate change adaptation. One problem with such directed efforts is that some future predictions are still uncertain, especially local precipitation patterns which are of crucial importance in agricultural systems.

Social and economic ties between different groups of peoples are beneficial in times of crisis (Bates 2000). Groups hit by adverse climate conditions such as floods or drought can acquire resources from other groups not experiencing the same problems (e.g. due to reliance on different agricultural techniques, use of different resources and ecosystems, or local variation in climatic conditions). Muya (2006) provides the example of the Wazigus in the Tanga region of Tanzania who are prone to drought conditions and get maize and other grain supplies from the neighbouring Wasambaa or Wabondei farmers in the same region or from other outside regions.

However, Pendergraft (2000) using various experiences and cases from farming communities in East and Central Africa shows that with
impending climate change some of these reciprocal systems may break down as certain tribal groups may become more permanently disadvantaged. Proctor (1998) states that many climate change risk-aversion strategies depend on different crop species and varieties, as well as on access to wild resources and ecosystems. Hence, agricultural policies such as permanent settlements can hinder indigenous coping mechanisms. In Eastern Africa, for example, various ethnic groups have traditionally tended to respond to drought by leaving their main settlements in the savannah and migrating to rainforest areas in times of drought. In most countries in the region such as in Tanzania, government settlement policies prohibited people from traditional temporary migration. So even though the government provided food aid during the drought, some of the people had no seeds to re-establish agriculture after the end of the drought.

Experience in Eastern and Southern Africa has also shown that markets may undermine indigenous coping strategies if traditional crop species and varieties are replaced by high-input, high-yielding commercial seed varieties susceptible to pests, diseases and climate variation. However, in some cases, markets may also help people cope with climate change if there is food and other resources to buy in times of crisis. Benefits of newly created opportunities (e.g. markets) are determined, not surprisingly, by factors such as power relationships within and among groups. Powerful individuals, households and groups may appropriate new opportunities presented by climate change and monopolize resources threatened by climate change. Many indigenous African communities not only inhabit marginal areas, but also are politically and economically marginalized. They are extremely vulnerable and yet are forced into new situations, such as markets, where their indigenous knowledge and skills are not applicable (Muya 2006).

**Conclusion**

The chapter demonstrated that indigenous African communities, like other indigenous communities in other parts of the world, have for centuries developed unique and complex knowledge systems of climate change adaptation in various aspects of livelihood including food security. This is due to their great reliance on their natural environment for survival. This wealth of knowledge which is increasingly being lost because of its oral transmission and the dominance of western systems of knowledge needs to
be documented and protected for its sustainability and for the well-being of future generations. Currently their experiences and interpretation of climate change are influenced by both the cosmology and mass media.

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**Contributors’ information**

Hassan O. Kaya, Research Office, Govan Mbeki Centre, Westville Campus, University of KwaZulu-Natal, Private Bag X54001, DURBAN 4000

E-mail: kaya@ukzn.ac.za

Yonah Seleti, National IKS Office, Department of Science and Technology, Private Bag X894, Pretoria 0001, South Africa

E-mail: Yonah.Seleti@dst.gov.za
Evaluating Small Reservoirs as Option for Climate Change Adaptation Strategy and Sustainable Rural Livelihoods

Ernest Nti Acheampong
Jean-Philippe Venot
International Water Management Institute (IWMI), Accra, Ghana

Abstract
In the face of climate change and variability in semi-arid Ghana, small reservoirs offer a reliable source of water for multiple uses to improve food security and reduce poverty. Past shortcomings in planning and investment approaches have led to uncontrolled investment costs often making small reservoir projects more expensive. Nonetheless, donor agencies continue to invest in small reservoirs, perceived as a more viable adaptation strategy to climate change. The study examines the development process of small reservoirs and their impact based on their performance, and contribution to mitigating climate change effects and improving rural economic livelihoods. Despite some level of success, most of the small reservoirs have performed below expectation. Their contribution to the economic livelihood of users has not been remarkable given the substantial investment in small reservoir development. Both technical and managerial constraints have accounted for their poor performance. Analysis of the 135 out of 232 small reservoir sites (in the Upper East region of Ghana) that were detected by remote sensing in both the 1999-2001 and 2005-2006 landsat images indicated that the surface areas and the corresponding volumes of the small reservoirs were significantly lower in 2005-2006 than in 1999-2001. This was mainly attributed to the decline in rainfall in 2005-2006 since 1999-2001. Variation in actual storage can give some insights on the potential benefits of small reservoirs in a climate change context where rainfall is expected to decline.
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(and surface runoff to increase). On average, the volume of water stored in small reservoirs was 12% lower in 2005-2006 than in 1999-2001. This is an indication that small reservoirs are effective buffers against drought, as can be expected. The effectiveness of small reservoirs to buffer rainfall deficits depends on the biophysical characteristics of the area (size of the watershed) and where they are located as well as on the design (notably, the spillway characteristic). The chapter suggests that in dealing with emerging challenges of climate change, small reservoirs development requires a comprehensive diagnosis of planning and technical designs that shape small reservoirs development, whilst understanding conditions under which small reservoirs can yield their full potential.

**Keywords:** Small reservoirs, food security, livelihoods, challenges, climate variability, constraints

**Introduction**

The semi-arid region of Ghana is predominantly rural, poor and dependent on climate-sensitive livelihoods. Behind the prevalence of poverty and food insecurity in the region is the high risk of climate variability and change. It is expected that the impact of climate change and variability would adversely affect rural livelihoods by way of reducing crop production, crop pest insurgence, disease prevalence and seasonal water losses, if well-suited adaptation mechanisms are not implemented (UNDP 2010).

Water resource tends to be a limiting factor to agricultural development in semi-arid Ghana. Characterized by high climatic variability and long drought spells, the rural population which is mainly constituted of smallholder farmers is susceptible to crop failures and livestock losses. Whilst water resources may not be the only limiting factor in agricultural production in the semi-arid region (others include; high cost of agrochemicals, poor soil fertility, lack of credit and markets for farm produce and lack of knowledge on improved farming and post-harvest Practices), it often tends to be the foundation for any improvement in agricultural productivity.

Water availability can serve as an important contributor to curbing the impacts of climate change in Africa. By increasing adaptive capacity of water storage, we can reduce vulnerability to climate change impacts, making water available for food production, livestock and domestic purposes, as well
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as control flooding (McCartney & Smakhtin 2010). To this effect, recent projects by International Water Management Institute (IWMI) (for example, rethinking water storage projects) have promoted water storage as a major component of climate change adaptation strategies.

The development of small reservoirs (a local innovation) particularly in semi-arid Ghana is viewed as a viable intervention to promote food security and mitigate the impact of climate change in semi-arid regions (Growth Poverty Reduction Strategy 2003). They provide great relief during water scarce periods (dry seasons) by serving multiple uses in rural communities (Liebe et al. 2007). Small reservoirs fuel rural socio-economic livelihoods (domestic use, livestock watering, construction etc.), and is of vital interest to dry season irrigation.

Over the past two decades, there have been substantial investments in the construction and rehabilitation of small reservoirs in Ghana. Different agencies implemented small reservoir development through a series of projects at different periods with little or no coordination (Andreini et al. 2009). Whilst small reservoirs (also known as small dams) are known to offer significant performance advantages over large-scale dams within irrigation investment projects (Inocencio et al. 2007), after two decades of small reservoir experience, it is argued that many have performed below expectation (Faulkner et al. 2008; Mdemu et al. 2009). In addition, there is emerging evidence of small reservoirs contributing towards environmental deterioration – in terms of erosion, siltation, pollution and decreasing water quality – and adverse health impacts (Boelee et al. 2009; Laamrani et al. 2006), both of which threaten their long-term sustainability (Andreini et al. 2009). In spite of this, small reservoirs appear high in demand among local communities; a priority for national governments; and continue to attract funding from international development agencies (Venot & Cecchi 2011).

For continuous investment into small reservoir development, it is necessary to show their value by way of evaluating their performance and contribution to mitigating climate change impacts and improving livelihoods.

Problems associated with the implementation of small reservoir development projects are numerous, ranging from technical issues such as poor design of irrigation systems, unsuitable site, topography, porous soils with high percolation and evaporation losses (Liebe 2002) to economic constraints like access to markets and social shocks such as forced relocation, lack of compensation of lost land, conflicts, etc. (Laube 2005). There is an apparent linkage between the various components of the
development process of small reservoirs, from the planning stage through the tendering process and awards to contractors, to design and construction and finally, operation and management. Understanding the entire process of small reservoirs using a holistic approach assists in unravelling the complex dynamics that surround small reservoirs development.

This chapter looks at the process of small reservoir development as a livelihood intervention, and indigenous adaptation strategy for climate change in semi-arid Ghana. The objectives are to examine and analyse (how and in what ways): (i) development and management of small reservoirs for multiple uses (access, use and control, and its implication on climate change and livelihoods); (ii) the mechanisms in place to govern and regulate small reservoirs from the local level through to district and national levels; (iii) the institutional processes that stakeholders utilize to claim their interest and stakes in the use of small reservoirs (both formal and informal); and (iv) adaptation strategies in the midst of the changing climate and variability.

The key questions that the chapter seeks to answer include:

- What is the level of performance of small reservoirs?
- What has been the path of small reservoir development?
- What are the constraints and setbacks that limit the full potential of small reservoirs?
- What informs decisions on small reservoir use, operation or management?
- How do small reservoirs serve as an adaptation mechanism for climate change and climate variability?

This chapter highlights that small reservoirs have yielded mixed output performance but affirms their contribution as a suitable adaptation strategy to mitigating climate change impacts. Section 2 describes the historical development and characteristics of small reservoirs in Ghana. Section 3 describes the methodology for this study. Section 4 looks at the results and discusses aspects that highlight the essential contribution of small reservoirs in spite of the challenges that constrain their performance.

**Small Reservoir Development in Ghana**
Semi-arid Ghana is known for its recurrent droughts over a long period. As a means to reduce the impact of drought and serve as soil and water
Small Reservoirs as Option for Climate Change Adaptation Strategy

conservation measures, the local people developed small dug-outs which accumulated and stored run-off water during the rainy season. During the dry season when water becomes scarce, small dug-outs offer an important source of water for diverse uses, particularly livestock watering, relieving the people of long distance travel for water.

Government involvement in small reservoir development began during the era of Ghana’s independence (late-1950s to mid-1960s). Small reservoirs have been promoted to deal with inter-annual rainfall variation and provide water storage for supporting multiple uses (irrigation, livestock watering, domestic, construction etc.) during the dry season. Between the late 1960s and early 1990s, only few small reservoirs were constructed (Fig. 1). In the mid-90s and 2000s, several donor-led development projects (IFAD’s UWADEP and LACOSREP I & 2, World Bank’s CBRDP and VIP) triggered substantial investment in the construction, rehabilitation and upgrading of old small reservoirs to boost agricultural production. Today approximately 1000 small reservoirs with an irrigation potential of 5000 to 10000 ha are distributed across the country. Most of the small reservoirs (354 out of 1000) are concentrated in the Upper East (UER) and Upper West (UWR) regions of Ghana which are prone to high climate variability and extreme weather.

**Figure 1: History and Spatial Distribution of Small Dams in Ghana**

![Graph showing the history and spatial distribution of small dams in Ghana.](image)

Source: Adapted from MoFA/GIDA Database (2008)
Description and Characteristics of the Study Area
The UER region covers a total geographical area of approximately 8842 square kilometers, which constitutes about 2.7 percent of the total land area of the country. The region is bordered to the north by the Republic of Burkina Faso, to the east by the Republic of Togo, and to the south by the Northern Region of Ghana.

Soils are mainly developed from granite rocks. They are shallow and low in fertility, weak with low organic matter content and predominantly coarse textured. Erosion is a problem. Valley areas have soils ranging from sandy loams to salty clays. Soils are more difficult to till and are prone to seasonal water logging and floods. Vegetation in the region is savannah woodland characterized by grass with scattered drought resistant, important economic trees such as Vitellaria paradoxa, Parkia clappertoniana and Baobab. The heterogeneous collection of trees provides all domestic requirements for fuel wood and charcoal, construction of houses, cattle kraals and fencing of gardens. The shorter shrubs and grass provide fodder for livestock.

The climate is characterized by one rainy season from May/June to September/October. The mean annual rainfall during this period is between 800mm and 1200mm. Rainfall is erratic spatially and in duration. There is a long spell of dry season from November to mid-February, characterized by cold, dry and dusty harmattan winds. Minimum temperatures could be as low as 14 degrees centigrade at night, rising up to 40 degrees centigrade during the daytime. Humidity is, however, very low, making the daytime high temperature less
uncomfortable. Of particular concern is the intensity of rainfall that often exceeds the soil’s infiltration rates causing surface run-off, without replenishing soil moisture and groundwater (Liebe et al. 2005). There is increasing population demand for scarce water coupled with high climatic variability. This makes water resources for agriculture woefully inadequate and crop production highly risky and vulnerable to water stress and fertility stress, resulting in frequent crop failures and lower yields.

In spite of harsh soil and climatic conditions, rain-fed agriculture is the predominant driver of the rural economy and engages a very high percentage of the rural population. The majority of households are mainly subsistence farmers who grow rain-fed crops in the rainy season (April to September). Millet, sorghum, maize, and groundnuts are the principal crops grown during the wet season. Small reservoirs play a pivotal role in generating income from irrigated onion, tomatoes and other vegetables during the dry season (November to March).

**Figure 2: Small reservoirs concentrated in Upper East region**
Characteristics of Small Reservoirs

Surface runoff water from ephemeral and intermittent streams that occur during the wet season are captured and stored in small reservoirs during the rainy season and made available for later use. Small reservoirs usually have one or two inflows and are located in stream and river inland valleys, provided the undulating landscape makes enough difference in elevation to facilitate the construction of a reservoir (Liebe 2002). The water captured in small reservoirs is utilized in multiple ways (irrigation, domestic use, livestock watering, and brick making) especially during the dry season when most other sources of water are dried up.

From the field visits which were supported by the aerial map, small reservoirs have an estimated flood area at full supply level (FSL) ranging from 3 to 14ha with a storage capacity up to 1 million cubic meters (MCM). All small reservoirs have earthen embankments with a length range of 200m to 400m. As a measure to check erosion, vetiver grasses are grown on the side of most dam walls but the grasses are not adequately maintained at the majority of these dams. The presence, dimension and quality of a spillway are of utmost importance for the dam’s durability. When the inflow of runoff water exceeds the storage capacity of a reservoir, spillways allow excess water from the peak flows to drain out of the reservoir in a controlled way. The design of spillways and dam heights is normally based on design floods, i.e. the maximum probable floods that are expected to occur at certain return periods (Liebe 2002). Small reservoirs are equipped with irrigation facilities ranging from motorized pumps to wells and canals. Irrigable areas are estimated from 5 to 25ha and in majority of the dams, irrigable areas are underutilized.

Methodology

The study adopted a three-stage approach. First, an inventory of available primary and secondary data on small reservoirs was made. Second, a Participatory Rapid Appraisal (PRA) was conducted in the UPR of Ghana where most small reservoirs are located. The PRA consisted of organizing working sessions with the Agricultural Extension Agents (AEAs) from the Ministry of Food and Agriculture (MoFA) in each district capital of the region. Detailed information collected included: (1) the characteristics of the reservoirs; (2) their design purposes and actual uses; (3) their level of performance; (4) the constraints faced by the communities; (5) the benefits derived from using the
small reservoirs; (6) the local institutional arrangements and modes of management. Detailed studies involved participatory exercises (focus group discussion, transect walks), semi-structured interviews with individual small reservoir users and key informants interviews in the community (local elected representatives, head of organizations, customary authorities, representative of Water User Associations). The aim was to gain a qualitative understanding of the multiple uses and perceptions of small reservoirs.

In addition, key informant interviews were conducted with policy-makers in the ministries of Water Resources, Agriculture, Irrigation and Environment at both the national and local levels, donors and technical development partners (International Fund for Agricultural Development, World Bank, German Development Cooperation etc.), elected officials of local executive bodies (districts), and other key informants to explore the implementation and planning processes of small reservoirs projects in Ghana. The study employed performance indicators that drew from physical, social and economic characteristics to create a balance in assessing the performance of small reservoirs in contributing to the livelihoods of beneficiaries. These performance indicators included: 1) the current status of the physical conditions (infrastructure) of the small dam systems; 2) water availability, looking at whether water is available in the small dam throughout the year or dries out; 3) operation and maintenance of small dams; 4) equitable access, i.e. to what extent are all water users able to access water from the small dam fairly; 5) the dams’ importance or value to the community; 6) Activity level of Water Users Association, i.e. do they meet regularly, taking decisions on the dam’s operation and management; 7) Water levy or fees collection rates, i.e. the number of water users who pay water user fees per season. Individual rankings for the various indicators were aggregated to obtain an overall ranking for each reservoir.

Third, remote sensing data for small reservoirs were collected for two seasons in a five-year interval (1999-2001 and 2005-2006). The surface areas and the corresponding volumes of the small reservoirs were analysed. This process gives an indication of the variation (increase or decrease) in the size and volume of small reservoirs over the five-year period.

**Results and Discussion**

**Performance Indicators**

The recent interest in re-investing in small dams prompts the evaluation of
small dams operation and impact on socio-economic livelihoods over the years. Performance evaluation is an essential management tool that brings out the successes and flaws of small dams in water delivery for multiple purposes (irrigation, livestock, brick making etc.). In assessing the performance of small reservoirs, we gain insight into how their management processes, physical, social and economic characteristics, influence the dam’s performance. Obtaining this vital information would aid implementers to plan and execute small reservoir projects adequately, and also assist farmers and other water users to plan and utilize water more productively.

In their assessment, Agricultural Extension Agents ranked more than 50% of small dams in the underperforming categories (1 and 2). The highest number of dams (74 out of 232) fell under the ‘very poor’ performance ranking representing 32% of the total small reservoirs. Approximately 63 small reservoirs are performing poorly (ranked 2) which represent 27% (second highest) of the total reservoirs. A total of 137 small reservoirs were said to be under poor performance which represent more than 50% of the total reservoirs (fig. 3).

**Figure 3: Performance ranking of small dams in the Upper East region**

![Performance ranking of small dams in the Upper East region](image)

Poor performance (1-2) of small dams reveals technical and infrastructural defects such as faulty valves, broken dam walls or canals, leakage, etc. which may have been caused by poor maintenance or poor design and construction.
As evident in some reservoirs, the improper design and limited technical knowledge of some contractors in small reservoirs construction have not only rendered some unusable but has also proven to be costly: within the span of 10 years some small reservoirs have been rehabilitated twice or thrice due to the poorly executed projects. The FAO/CP support mission report (2007) on small reservoirs confirms the assertion of faulty design and poor quality of work due to a lack of technical knowhow which caused several dams to break down before they were even commissioned.

Most poor performing dams are characterized by broken canals which cause large quantities of water loss. In the absence of proper up-keep canal water is lost through seepage or percolation in earth canals at the field level. Water loss occurs through seepage and leakages in dam walls and irrigation canals remain stagnant in some parts of the irrigable area rendering such places difficult to cultivate.

Though the majority of small reservoirs in the study area are underperforming, close to 40% are performing averagely or above average based on available performance indicators (fig.2). This proportion is very significant, providing the assurance of small reservoirs’ capacity to perform when proper management strategies are executed.

Administrative/Institutional Setbacks to Small Reservoirs Development
The small reservoir development process is confronted with many challenges, which in many cases have translated into their poor status and subsequent poor performance. During the planning process of small reservoirs, bidding and contractual arrangements tend to be crucial to how the development of small reservoir projects may shape up. Shady and corrupt practices that enshrined these processes in the past have resulted in poor design and construction of small reservoirs; lack of technical knowhow on the part of contractors (FAO Mission Report 2007) has been detrimental to small reservoir development; and long and delayed administrative procedures by government agencies tend to have a negative impact on small reservoir development projects. In the end, the cost of a project rather becomes more expensive or sometimes the project is completely abandoned due to a lack of payments. A major recurring situation in small reservoir development has been the protracted length of construction and completion which tends to raise development costs due to high variation; small reservoir projects are
abandoned and/ or re-awarded to different contractors often affecting the quality of work (see Venot & Andreini, forthcoming for future information).

**Institutional Arrangements, Decision Making and Governance of Small Reservoirs**

The decentralized process establishes the democratically elected and semi-autonomous District Assemblies (DAs) as political authorities in charge of activities at the district and sub-district levels (Laube 2009). However, due to limited funding and capacity for the development of their respective districts (Asibuo 2000; Inanga & Osei-Wusu 2004), regional and national influences still predominate. For instance, small reservoir development projects are planned and initiated at the national and regional level. National institutional innovations have targeted improved water quality such as for drinking water with little or no impact on raw or unimproved water sources (Eguavoen 2008) such as small reservoirs.

Although DAs have jurisdiction over all small reservoirs located within the district, the lack of financial and technical capacity limits their effectiveness in controlling small reservoirs. The District office of the Ministry of Food and Agriculture (MoFA) exercises oversight responsibility over small reservoir management through Agricultural Extension Agents. The Ghana Irrigation Development Authority (GIDA) has the sole responsibility as government representative to formulate, develop and implement irrigation and drainage plans for year-round agriculture production in Ghana. In small reservoir development, GIDA supposedly plays a role in construction and major maintenance activities.

Local water management institutions are multiple, connected one to another and to other levels of decision making (Eguavoen 2007). For example, respondents listed 5 to 10 institutions that contributed to different and complementary roles in the governance of small reservoirs. Traditional authority still plays an important role over small reservoirs perceived as a common property, often held in trusteeship by chiefs or spiritual leaders. Traditional institutions function to activate and enforce social norms of behaviour through established patterns of authority and leadership (Gyasi et al. 2006). Chiefs, elders and spiritual leaders are known to settle disputes, resolving conflicts and maintaining social cohesion. They also enforce local rules governing water resources by threatening perpetrators with spiritual or social sanctions, sometimes in co-operation with local administrative or
political bodies (Laube 2009). They hold the prerogative to allocate land for irrigation, sanction communal labour for small reservoir maintenance and strengthen the Water Users Associations to implement regulations on the operation and management of the small reservoir system.

**Adaptation Mechanism to Impact Climate Change and Variability**

An analysis of the 135 small reservoir sites detected by remote sensing in both the 1999-2001 and 2005-2006 landsat images indicate that the surface areas and the corresponding volumes of the small reservoirs were significantly lower in 2005-2006 than in 1999-2001 (figure 3). This is mainly due to lower rainfall in 2005-2006 than in 1999-2001 (figure 3). Variation in actual storage can give some insights on the potential benefits of small reservoirs in a climate change context where rainfall is expected to decline (and surface runoff water to increase). On average, the volume of water stored in small reservoirs was 12% lower in 2005-2006 than in 1999-2001. At the same time, the region recorded a rainfall deficit of 35%. This is an indication that small reservoirs are effective buffers against drought, as can be expected. There is no clear evidence whether larger reservoirs provide ‘better’ buffers than smaller one. The effectiveness of small reservoirs to buffer rainfall deficits depends on the biophysical characteristics of the area (size of the watershed), where they are located as well as on the design (notably, the spillway characteristic).

**Figure 4: Surface area and volumes of small reservoirs: A 5 years evolution (2001-2006)**
Currently, the strategic importance of small reservoirs in the context of climate change lies more in sustaining livestock-based livelihoods than crop or irrigation-based livelihoods. This is evident in the adaptation strategies that communities employ during the period of drought (Mbinji 2010). The reduction in irrigation activities is the most common strategy considered in
times of drought or water stress situations. This practice is to conserve limited water for livestock, which is considered a priority in the period of drought.

**Conclusion and Recommendation**

Small reservoirs development has encountered diverse challenges ranging from technical to managerial issues, resulting in their inability to yield their maximum potential. The chapter points out that small reservoirs performance have been mixed. Majority of them are performing below expectations based on defined indicators. From the conception stage, small reservoirs projects are faced with rather complicated administrative and contractual setbacks that pose a threat to the successful execution of the project and subsequent performance of small reservoirs. At the field or local level, shortcomings related to technical design and construction include uncoordinated institutional arrangements for decision making, lack of managerial and organizational capacities, poor market access and public apathy to small reservoirs. These challenges seem to contribute to the poor performance of small reservoirs. Despite these setbacks, small reservoirs contribute immensely to the socio-economic livelihoods of beneficiaries and also as a climate change adaptation strategy. They act as a buffer during the season of drought by providing water for diverse uses. Small reservoirs encountered just 12% loss in the volume of water stored at a rainfall deficit of 35% over a five-year period. This reveals the potential of small reservoirs to lessen the impact of climate change and variability if appropriate water management strategies are put in place. Efforts to enhance sustainable small reservoir development should be based on appropriate intervention suited and adapted to each locality, taking into account the local knowledge, local opinion and the local aspirations.

**References**


**Contributors’ Information**

The Role of Indigenous Knowledge Systems in Climate Change Adaptation and Mitigation: Case Study of the Mijikenda Community, Kilifi County, Kenya

Roxventa A. Ongugo
Samuel Kimani
Kenyatta University, Nairobi, Kenya

Abstract
Traditional knowledge systems are functional entities and institutions that serve as custodians of specialized areas of traditional knowledge and indigenous innovations. Traditionally, African farmers have used indigenous knowledge to understand climate and weather patterns, to make decisions about crop and irrigation cycles. Climate change affects many indigenous communities throughout the world. Environmental degradation resulting from increased human activity is a major threat, especially to forests, rivers and lakes and even farmlands in general.

This chapter focuses on the Mijikenda community from the coastal part of Kenya. Over the centuries, the Mijikenda have accumulated a wealth of knowledge in traditional resource-use and management systems, and associated practices and customs related to forests, agricultural and marine resource use. However, the Kaya forests (sacred forests) are still sacred ancestral landscapes, visited for rituals and traditional prayers by the Mijikenda.

It is important to explore the role played by traditional knowledge systems in adaptation to climate change.
Within coastal indigenous communities, focus group discussions with indigenous community members, and district forestry and agricultural authorities with strong emphasis on active reliability with traditional knowledge systems were used to collect detailed information among the Mijikenda living in Kilifi County. Analysis of the data was done using SPSS software. Findings from the study were presented using simple statistics. Qualitative analysis was used to show how traditional knowledge is used as a strategy in enhancing adaptation to climate change effects.

**Keywords:** Indigenous Knowledge Systems, Climate Change Adaptation and Mitigation, Mijikenda Community, Kilifi County, Kenya

**Background**
There is growing awareness of the role of indigenous and local communities in the management of protected areas designated by governments. Of equal importance are the sites and landscapes managed by communities themselves. The contribution of these communities and their TK innovations and practices to the conservation and sustainable use of biodiversity in and around protected areas is gradually being recognized (John & Jean 2009). This paradigm shift from exclusionary protection of indigenous communities towards inclusive and local participatory management models poses many challenges. Many ILCs living traditional lifestyles that conserve ecosystems believe in community, rather than individual rights. They share a conception of the self not as a unit separate from the world over which they have proprietary rights, but rather an understanding of the self as integrated with the land and embedded within an ethical relationship (Dudley 2008).

TK then is not value-neutral information, but is interconnected with a way of knowing that is a result of an interaction between ILCs and the land that is rooted in cultural practices and spiritual values, enshrined in customary laws (John & Jean 2009). Notably, it is this bio-cultural relationship (see Diagram 1), not their proprietary rights over TK, that have contributed to centuries of *in situ* conservation of biological diversity. ILCs have consistently highlighted their integral relationships with the environment at various international meetings and have worked to integrate their views into international laws and other ILC declarations. The ILCs’ declarations emphasize spiritual, cultural, and reciprocal relationships with
the land, interconnectedness with all forms of life, custodianship of territories and knowledge for future generations, ethical use and treatment of all forms of life, and opposition to understanding life and knowledge as property.

**Diagram 1**

**Introduction**

TK refers to the knowledge, innovations and practices of indigenous and local communities, embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity. In Kenya, TK encompasses IK, often held by indigenous communities and intangible knowledge held by the local indigenous community. TK is created and held
by individuals, a family, clan, tribe or whole community and at times by several communities. IK is embedded in traditional knowledge systems, which each community has developed, maintained and passed on from one generation to the other in its local context. It is evolving all the time as individuals and communities take up the challenges presented by their social and physical environment. Unfortunately, IK, and TK are being eroded due to changing lifestyle in rural areas, as technology and western culture change livelihoods of community members, and cultural preferences.

Traditionally, African farmers have used IK to understand weather and climate patterns to make decisions about crop and irrigation cycles (ICPAC 2005). Climate change is affecting many indigenous communities throughout the world. Environmental degradation resulting from inappropriate human activity is a major threat (Kothari 2006). For example, the loss of traditional farming techniques has led to damage as families adopt modern techniques that are seen as more sophisticated but are perhaps not suited to the specific regional and climatic conditions, causing decreased crop yields, and other issues.

The lack of legal recognition and protection has led to a situation where custodians of knowledge and innovation derived from traditional knowledge systems and traditional knowledge are not rewarded for the contributions rendered to society (Kothari 2006). For climate change adaptation, it is important to determine if indigenous knowledge still plays a role now and in the future for livelihood security. The fact that indigenous communities have survived for centuries in hazardous environments suggests it does.

Communities (indigenous people) have always had their own laws and procedures for protecting their heritage and determining when and with whom it can be shared. Indeed, many traditional societies have their own custom-based intellectual property systems, which can be very complex, vary greatly and often differ considerably from western concepts of intellectual property.

Scientific weather forecasts, however, are formulated on a much larger scale and are presented in a manner unfamiliar to farmers (Evans 1967). This creates a dilemma for those who recognize the limitations of traditional climate forecasts but are unable, due to lack of resources or information, to use scientific ones. To address this problem, researchers will endeavour to integrate IK into scientific climate forecasts at the local level,
where it can be used to enhance the resilience of communities vulnerable to climate change (ICPAC 2005).

Miji Kenda Tribe

Mijikenda literally means *nine homes* or *nine homesteads* in Swahili, referring to the common ancestry of the Mijikenda people. The nine Mijikenda sub-tribes are believed to be nine different homes of the same tribe. Each sub-tribe speaks its own dialect of the Mijikenda language. Among the nine Mijikenda sub-tribes, the *Giriama* and the *Digo* are the most well-known, most populous, and most dominant along the Kenyan coast. The other seven sub-tribes are the *Chonyi, Duruma, Jibana, Kambe, Kauma, Rabai* and *Ribe*. It’s very common for other Kenyan tribes to refer to all Mijikenda people simply as *Giriama*.

Mijikenda oral history traces the origin of the tribes to the southern regions of Somalia. It is believed that the Mijikenda people escaped constant attacks from the Oromo and other Cushitic tribes, and settled in the coastal ridges that were easier to defend.

The Mijikenda culture revolves around clans and age-sets. A Mijikenda clan consists of several family groups with a common patriarchal ancestor. Traditionally, each clan lived in one fortified village built in a cleared area of the forested ridges. A person’s age-set determined their role and social standing within the clan and elaborate rituals were often held for members graduating from one age-set to another.

Each Mijikenda clan had their own sacred place known as *Kaya*¹, a shrine for prayer, sacrifices and other religious rituals. These kayas were located deep in the forests and it was considered taboo to cut the trees and vegetation around them. The kaya elders, often members of the oldest age-set, were deemed to possess supernatural powers, including the ability to make rain.

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¹ *Kaya* – Mijikenda sacred place, shrine for prayer, sacrifices and other religious rituals
Agriculture is the main economic activity of the Mijikenda people. Their most important cash crop is the coconut palm; whose products include oil extracts and palm wine. Its fronds are used for roofing and as material for making baskets, mats, brooms and other weaved products.

Other important cash crops include cashew nuts, oranges and mangos. Where favourable weather conditions allow, some Mijikenda people also grow annual crops such as maize, sorghum, millet, and beans.

Fishing is another important economic activity for the Mijikenda people. Miji Kendas actively fish in the neighboring Indian Ocean, where their ‘daily catch’ forms part of the seafood supplied to Kenya’s coastal hotels and residents.

**Traditional Protection Systems Used in the Kayas**
The traditional protection mode used in the coastal forest by the Kayas implies something set apart, holy or revered. It is often associated with the secret or forbidden. The main objective of the traditional management of sacred sites is to maintain their separateness or sanctity by controlling access to them (Burgess 1998). This is achieved largely through the strength of spiritual beliefs and social rules and norms. Active physical policing of sacred places by custodians have tended to be the exception rather than the rule. More commonly, taboos and other religious observations have been
applied, regulating access and conduct at the sites, threatening dire punishment from the spirit world for those who flouted community rules (Robertson 1986). These have proven fairly effective in reinforcing self-restraint among individual members of the group.

If a breach does occur, purposely or not, intervention or intercession by spiritual leaders is required to ward off harm to the trespasser. The Kaya communities conform to this pattern (Beeton 1998). The most sacred areas tend to be set at the centre of the forest. The Kayas are approached from only a few well-trodden and defined paths. Historically, use of any other trail but these paths and gates signified bad faith and enmity, and thus met with hostility from the inhabitants of the Kaya. The cutting of trees and other activities that could potentially cause damage to the forest around the Kaya and sacred spots is strictly forbidden by the Kaya Elders, especially considering that structures built for ritual purposes used material from the Kaya forest. These sorts of destructive activities include collecting or removing dead logs or twigs or any other forest material. One keeps to the traditional paths and avoids wandering freely in the forest. Trampling vegetation and disturbing secret sites and grazing livestock in the forest are forbidden. Uncommon animals, particularly large snakes, were to be left alone if encountered. In addition to these restrictions on physical interactions at the site, there were behavioural controls as well. These were designed to maintain the integrity of the Kaya. These restrictions emphasises etiquette and respect as well as control of physical and emotional passions. However, all members of the Kaya community, including women, were entitled to visit the site if they so wished. They could also use the site under the Elders’ guidance for ritual and ceremonial purposes. The penalty for infringement varied, depending on the magnitude of the transgression, but it usually consisted of fines of livestock or fowl, which were then sacrificed to appease offended spirits (Nyamweru 1998).

**Biodiversity Value and Climate Change**

Sacred sites have been important for biodiversity conservation all over the world. Botanical surveys of coastal forests in Kenya have provided and continue to provide information on rare and interesting plant species in the Kaya forests. These sacred forests are the only known locations of certain plant species. This is especially important, highlighting their status as a
traditional and modern conservation legacy. The Kayas form a key component of the complex mosaic of rich Eastern African coastal forests.

The Eastern African coastal forests have been described as a heterogeneous group of isolated evergreen or semi-evergreen closed-canopy forests within 60km of the Indian Ocean – land usually on low hills rising to not more than 600 meters. They stretch from southern Somalia in the north through Kenya and Tanzania to Northern Mozambique in the south, and are part of White’s ‘Zanzibar Inhambane Regional Mosaic’ (White 1983). They are regarded as important for biodiversity conservation globally, a conclusion drawn from the accumulated findings of scientific surveys and research in the region over many years.

**Overall Study Objective**

The study explores the role played by traditional knowledge and bio-cultural systems in adaptation to climate change of the Mijikenda people. The Mijikenda demonstrate a traditional knowledge system that has mechanisms for ensuring sustainable utilization of the biological resources, as well as mechanisms for adapting to varying climatic conditions characterized by temperature and high rates of carbon dioxide in the atmosphere. These include principles of land use and tenure equity, management, and hierarchical relationships in the management of the resource for the entire community (Evans 1967). Through these mechanisms, traditional institutions, led by community elders, managed the kaya forests as communal property until the introduction of central governance. The elders were/ are the primary custodians of the sacred forests that were respected by all within and outside the community. The bio-cultural systems have historically played an important role in maintaining the integrity of the natural forests and conservation of the biodiversity therein through sound agricultural practices. However, over time various processes have changed the effectiveness of the traditional governance system to conserve both agricultural and forest resources. These include anthropogenic factors, modernization, religion and formal governance institutions.
Study Area

The study took place in Kaya Fungo in Kaloleni in Kilifi County along the northern part of the Kenyan coast, and in Kaya Kinondo, which is in Kwale County on the southern part of the Kenyan coast. Kaya Kinondo forest is one of the oldest sacred forests of the Mijikenda people and is situated in Msambweni division in Kwale just along the Diani beach in the south coast of Kenya (see Figure 1). This is one of the most developed tourist destinations at the Kenyan coast. The forest is believed to have about 187 plant species, 45 species of butterflies and more than 48 bird species, of which two are endemic and one threatened.

The communities around Kaya Fungo are agricultural and livestock farmers while the communities around Kaya Kinondo are fishermen, livestock farmers and agricultural farmers.

Figure 2: Map of the Kayas at the Kenyan coast
Methodology
Kaya Fungo and Kaya Kinondo elders were interviewed for this study. Focus group discussions were held with the six Kaya elders who were randomly picked and six members from each group who represented the different economic activities performed by the community. There were also key informants from different government offices like the Kenya Forest Service (KFS) and the Fisheries Department. The study relied on secondary information i.e. books, journals, newspaper reports, internet resources and personal communications with targeted people, especially with some officers from the Kenya Resource Centre for Indigenous Knowledge (KENRIK) at the National Museums of Kenya (NMK).

Study Findings
Preliminary findings of the case study on the Mijikenda of the Kenya coast suggest that the indigenous communities are experiencing the effects of climate change, which are impacting their socio-cultural, economic, environmental and food security wellbeing. The communities are experiencing shifts in seasons including extreme temperatures, floods, prolonged drought, tidal patterns and ocean storms. These changes have led to shifts in their agricultural, forestry, livestock and fisheries practices including adaptation measures. These cultural adaptations include loss of practices and beliefs, and readopting the old traditions and beliefs of the indigenous community. Documented responses indicate a combination of contemporary government approaches and traditional bio-cultural management approaches to the agricultural and ecological livelihood challenges caused by climate change. These approaches attempt to ensure diversity and reduce risk from events such as drought, flood, or other extreme weather events, protecting agro ecosystems and ensuring food security. Traditional knowledge systems are also a valuable source of crucial information for agriculturalists on weather forecasting.

Based on interviews and focus group discussions around Kaya Fungo and Kaya Kinondo about agro ecosystems (crop and livestock) and fisheries in Kilifi and Kwale counties, the indigenous communities have observed notably new and worrying unpredictability of the weather conditions including timing of onset of rains. The rains are either too little or too much. Previously, droughts would occur once every ten years. Currently, droughts are more frequent and prolonged.
Agricultural Farming, Changes and Adaptive Capacity (Kaya Fungo)

Agriculture is the backbone of Kenya’s economy. Agricultural activities are commonly practiced within all arable parts of the country. Most of the households in Kaloleni run on mixed cropping with coconut farming as their main source of livelihood. The study revealed that there is a decrease in the vegetation from year to year, as indicated by indigenous communities, which has negatively impacted crop productivity due to climate change. The recent high temperatures have caused the disappearance of various species of plants that survived historically in different moisture regimes. The farmers have not been using organic fertilizers, leading to poor soil structure. This has increased the hardpan, reducing root penetration. Resultantly, the farmers are opening new farm land and leaving the existing cleared land unfarmed. Soil erosion has increased by free-ranging livestock, which cause more destruction than before as they forage. Charcoal burning has increased. Farmers lack innovative technologies but the Ministry of Agriculture has been instrumental in developing new crop varieties within the district (Kilifi). The traditional crops are no longer productive because of higher temperatures. Soil conservation is the biggest challenge the community faces with regards to agriculture, while protection of river banks also requires attention.

Some of the signs of climate change cited by the Ministry of Agriculture are: shrinking swamps and drying rivers; low crop production leading to a frontier shifting cultivation; loss of soil structures; fertility and formation of hard pans; high temperatures; increased soil erosion; and, decline in crop diversity.

New seed varieties have been introduced by the ministry, but the farmers still fall back to the indigenous crop species (orphan crops). A policy of planting 10% forest area in croplands has been introduced by the government to curb soil degradation. Zay pits are being established in hardpans – a novelty by the ministry (introduced three years ago), alongside the traditional trash lines. Coconut trees are encouraged to stabilize soil structures. Other tree planting in croplands, which is unusual in the area, is picking up with Casuarinas spp. the favourite as a commercial product. Traditional crops i.e. Muzihana spp. is on the increase, but legumes are preferred as a mitigation measure to climate change.

Kenya Agricultural Research Institute (KARI) ensures the biodiversity, through bulking of preference crop seeds and breeding new
species adaptable to the new climatic condition. Farmers are encouraged to diversify crop niches (spreading farms in different areas) to spread the risk of total crop failure. River bank protection – the rule of not farming within a stipulated distance from a wetland or conservation structure – is another mechanism by the ministry to combat climate change.

The farmers agree that farming is no longer sustainable for food security. There has been a need to change crop husbandry to mitigate the changes in their new environment and new climate. Climate change is not in their vocabulary, but they have noted the changes in their environment attributed to the new weather conditions. In older times rains were reliable, resulting in high food production. The traditional crops are the zuhuru, the black maize variety, kasto, which comes in two varieties, the small yellow seeded and the big (bomba), and Igawa, a fast-growing maize type. These were and are still a reliable harvest. Other crops are millet, simsim and cassava.

The usual two seasons (msika or maaki, or long rains, and vuli, the short rains) intermitted by one season in between has totally been replaced by two unreliable seasons, another indication of climate change affecting agricultural activities and production. The traditional Digo calendar, for instance, used to dictate farm activities and had only four days in a week i.e. day one to three, kwalula, kurima and kufusa respectively, were the working days. The fourth day, chipalala, was a market day and the day to address community issues; this has hence changed. In other areas for example in Kaloleni, the dialect changes, and ijuma becomes day one, kuramuka day two, kirimahir three and kwisa the last day. The natives followed this activity calendar stimulated by the larger moon calendar for cropping activities i.e. new moon spotting – no planting; full moon is the best time to plant. In science, this coincides with the tidal pulls which control rainfall. As such, working outside the traditional calendar is resulting in a change in agricultural output, causing low production.

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2 Kwalula – preparation of land for cultivation or the beginning of planting of crops.
3 Kurima – cultivating of land
4 Kufusa – to put the seeds in the land for planting
5 Chipalala – market day
6 Karamuka – beginning
7 Kirimahir – second season of cultivation
8 Kwisa – the last day of harvest
The cropping calendar has changed significantly from onset, initially March now May, for the long rains, and short rains which were expected in August sometimes don’t come. Farmers traditionally cleared farms in January awaiting the signals of rain onset i.e. *wingu kusima moto* (first clouds), or *konsoso* as held in Kaloleni. These are usually the false rains, and with the second clouds came the real rains for planting. Rains predictions were sighted when sea-side clouds formed and drifted for the new ones to form in the same position and also drift, but when they merge, rain falls.

Other signs of onset of rains were seen in indigenous trees, i.e. the flowering of *Tamarindus indica* and new leaves in deciduous trees like the *Acacia spp.* In the sea, emergence of *muchua marat*\(^9\), sea weed, was a signal to start planting. *Chiri mira*\(^{10}\) – sighting of a collection of stars – spelled the onset of rains for *kumbikia*\(^{11}\) (pre-planting) to start, awaiting the rains. The invasion of Nyoye (armyworms) before the rains and planting indicated that a bumper harvest would ensue. This was also a food (protein) supplement collected by boys. Mario – a bird species circling in a *nyenze*\(^{12}\) dance – indicated the coming of the rains. Crickets heard chirping away would also tell the rains are near.

Adaptation to these new changes includes use of machinery in the hard panned soils, application of pesticides, switching to new seed varieties for high yields, and introduction of new crop species i.e. planting in lines away from the traditional broadcasting (arguable) intervention and the use of animal traction. The ministry, however, is encouraging planting of traditional crops (the orphaned crop) i.e. cassava, millet, potatoes and traditional maize breeds, which are highly valued, able to resist diseases and withstand prolonged drought. The hoes have become bigger, a necessity to break the hard ground, and use of farm inputs is necessary to eradicate pests and increase yields. People have moved from mixed farming to mono-cultural agriculture.

Crop harvests fluctuate each season depending on the rains, seed variety and labour inputs. Storage facilities have remained traditional i.e. *ucha/luthanga* which are granaries (in-house) and processing is done by shelling, winnowing, smoking and ash-dusting of grains, with the seed grains left in the husks. Crop acreage has changed with population explosion from

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\(^9\) *Muchua marat* – sea weed that signifies the start of planting season  
\(^{10}\) *Chiri mira* – collection of stars that signify the onset of rain for pre-planting  
\(^{11}\) *Kumbikia* – start of pre-planting awaiting rains  
\(^{12}\) *Nyenze* – a dance by the birds indicating the coming of rains
big farms to small ones, limiting crop rotation. Emergence of floods and prolonged droughts are felt. The ministry appreciates ITK of farmers and uses the information to improve technologies. They rely on the locals for early warning signs.

**Livestock Farming, Changes and Adaptive Capacity (Kaya Fungo)**

Animal husbandry in the coastal region involves domesticated animals – cows, sheep, goats and poultry. Herders keep large numbers of animals as a sign of wealth and prosperity. With the increase in human population, demand for dairy has increased. The reflexive action of the farmers is to increase their stock. The arable lands being static, the farmers have to move their animals into rangelands as pasture becomes harder to obtain. Pressure on grazing land has increased as the carrying threshold is surpassed.

The impacts of climate change has accelerated the degradation of grazing land with long droughts, floods and runoff water on the bare lands further eroding the fields. The unpredictable rains have led to rivers and other water sources for watering animals remaining dry most of the year. Farmers have to move, nomadic style, with their animals in search of pastures and water. Animals from other areas – as far as North-eastern province of Kenya and Somali (in transit to the harbour or to slaughter houses) invades the pastures i.e. thousands of camels and cows destined for export to the Middle East are periodically offloaded in the area (Mariakani and Kaloleni) as they await shipment. This has further impacted on the already stressed pastures resulting in the deaths of animals, introduction of new pests and increased livestock diseases in the area. Rangelands have suffered the problem of a shared common area.

Farmers have been advised to destock and keep few healthy animals within the threshold of their pastures as a mitigation measure. Some farmers have relocated to greener pastures and permanent rivers as a survival strategy. They also lend out their animals to friends and relatives in other places until favourable conditions return, and then the animals are brought back home, a common traditional practice. Some have resorted to the conservation of rangelands by planting fodder crops, re-planting grazing lands and weeding the invasive species that have colonized pasturelands.

Another new phenomenon as climate change takes hold is making hay in times of rainfall when grasses are plenty. Farmers have learnt a new
pattern of grazing and start by moving their animals to the reserved/communal lands before returning home to their own lands, the opposite of historical patterns. The use of local herbs for livestock health is still prevalent as the ministry resources are not adequate. Traditional methods include the use of *kinyuido* herb for snakebites in livestock, or the remedy for a cow which eats her calf’s placenta, which prevents milk production. No scientific medicine exists but the natives have a soapy herbal cure. There has been a gradual change of breeds from the indigenous breeds to crossbreeds in the hope of phasing out local breeds and increasing production.

**Fisheries, Changes and Adaptive Capacity (Kaya Kinondo)**

The Kaya Kinondo sacred forest was gazetted by the National Museums of Kenya (NMK) and UNESCO as a national heritage forest, with support from WWF and the Ford Foundation. The forest has been a centre for the protection and conservation of various species and improvements in eco-tourism services. The forest receives visitors from all over the world, who pay to the community to visit the site. The management of this site takes into account the advice of the Kaya elders.

In addition to climate change affecting traditional livelihoods in the Kayas, it also affects traditional fisheries practices. The rising ocean acidity caused by increased carbon dioxide makes it more difficult for marine organisms such as shrimps, oysters, or corals to form their shells. Many important sea creatures, such as plankton that form the base of the marine food chain, have calcium shells. Thus the entire marine food web is being altered and there are ‘cracks in the food chain’. As a result, the distribution, productivity and species composition of global fish production is changing, generating complex and inter-related impacts. This interferes with the aquatic life of both plants and animals.

The most immediate effect of climate change in fisheries is that particular fish species might become extinct leading the overall fish catch per day to decrease devastating this income for the fisherman and creating higher fish prices for consumers. The water volume in the ocean is believed to be decreasing, as evaporation increases and no condensation takes place, also reducing rainfall. The high rainy seasons remain in September, October and November while the other months are low rainfall periods due to changes in rain patterns. When there is high sunshine, high volumes of fish are caught.
The changes that have been experienced in the fishing industry include:

- Increased number of fishermen in the industry leading to low volumes of fish caught by each fisherman; and
- Loss in fish species diversity, with some species threatened with extinction.

The strategies that have been adopted to counteract these effects include:

- Formation of beach management units to punish and penalize those who do not practice fishing according to recognised rules that ensure the continuation of the fishing resource; and
- The government has put controls on the net sizes to be used to prevent juvenile fish being caught.

Traditional methods have been put in place by the elders to help solve the problems around the resources e.g. quarrels and theft. Fishing practices have traditionally been passed from father to child as part of IK. However, this is now changing since communities are taking their children to school.

The organization involved in fisheries is Kenya Marine and Fisheries Research Institute (KMFRI). In the traditional set-up, in order to get a bumper catch and to prevent injuries while fishing, certain rituals and sacrifices are performed on the fishermen before they go to fish. This process is conducted by the elders. In the recent times, the rains have become unreliable, making farming an activity that cannot be depended upon. The farmers have been forced on several occasions to change the crop varieties that can adapt to the changing rain patterns.

Mitigation measures have been incorporated to conserve fisheries for common use. For example, the government introduced a governing body manned by the fishermen, the Beach Management Unit (BMU), which has embarked on a number of activities like cleaning the beaches of dumped materials (debris, tins, oil spills and polythene). The BMU replaced the traditional beach elders who were of an older generation, causing a loss of undocumented ITK held and passed on from previous generations.

Fishermen are being sensitized on aqua-business on- and off-shore, and being taught to divert fishing from the less productive waters. Proper
fishing gear is being used in lieu of destructive fishing equipment, for example the wing-net, a scooper. Other training on income generation is via the BMUs which have been given legal status. The number of fishermen is fairly constant in the beaches, as the fishing communities are usually local from Vanga, Pemba and Magati peoples.

More emphasis has been put on environmental conservation, including planting mangrove forests to prevent shoreline erosion and to support breeding grounds for fish. Control measures are placed on fish species rare in the range and shell collection is prohibited. The Traditional practice of zoning off areas from foreign fishermen who encroach have been reintroduced i.e. Pembians and Japanese fishing boats and there has been documentation of fish species in the local dialects (i.e. Tufi\textsuperscript{13} also Tasion different beaches) and information on still extant ITK in fisheries has been documented. The fisheries department relies on the fishermen for visible signs of degradation and other signs of climatic change as they are more familiar with the climatic changes and the physical environment of the area.

**Agricultural Changes (Kaya Kinondo)**
Drought has caused crops to rot on farms, or dry completely, lowering the final harvest. The farmers report that they are not receiving advice from the agricultural officers, on what they are supposed to do to improve their yield. The crops they grown include beans, cassava, marenje, pojo, green grams and maize.

Traditional crops are still grown by many farmers because of several advantages which include:

1. Fast germination
2. They are easy to weed
3. They are resistant to pests and diseases

The maize varieties grown include coastie and katumani, while the cassava species include nguzo and kigezo. Specific rules have been put in place for people to follow e.g. no one is to harvest and leave before the job is completed that day. Other activities on the farm are done systematically,

\textsuperscript{13} Tufi or Tafi – a type of fish found in the ocean
where the first elder does slashing as other activities follow. Harvesting is done while the elders sit in discussions and make appropriate decisions. The signs of rain that were used are:

- First cloud *mzima moto* – appears for first rain;
- Second cloud – rain-planting season;
- Different stars and clouds appear at the edge of the ocean, which symbolizes the coming of the rains;
- The grasses in the ocean (*muchawa*) change and stand upright; and
- Certain trees flower and seed.

The sale of raw maize used to be prohibited, but is currently allowed. Due to climate change, frequent droughts have occurred. Prolonged droughts have caused the death of livestock and crops leading to a dependence on crops and livestock from other regions. The community has done a great deal of environmental conservation to avert the situation. However, slowly, some changes are being realized. Trees are now being planted around the Kaya forest. After periods of long droughts, the community performs rituals using animals (cows, goats, chicken) for sacrifice to appease deity and bring rains. The effects of drought are varied and are categorized as social, environmental and economic.

**Economic Effects of Drought**

1. Loss of national economic growth, slowing down of economic development;
2. Damage to crop quality, less food production;
3. Increase in food prices;
4. Increased importation of food (higher costs);
5. Insect infestation; and
6. Plant disease.
Environmental Effects of Drought

1. Increased desertification – damage to animal species;
2. Reduction and degradation of fish and wildlife habitat;
3. Lack of feed and drinking water;
4. Disease;
5. Increased predation; and
6. Loss of wildlife in some areas and too many in others.

Social Effects

1. Loss of human life from food shortages, heat, suicides, violence;
2. Mental and physical stress;
3. Water user conflicts;
4. Loss of cultural sites;
5. Reduced quality of life which leads to changes in lifestyle; and
6. Food shortages.

Conclusion

It is evident that the Mijikenda communities of the coastal strip have experienced climate change as they go about their livelihoods initiatives and food production activities i.e. in agriculture – crop and animal husbandry, subsistence fishing, farm forestry and in the management and conservation of their forests – the Kaya forests. The interventions in the above activities apply indigenous and traditional knowledge (ITK) to mitigate climate change. However there are forces against embracing (ITK) – faith as practiced by some natives (Christianity and Muslim). Further, the application and adoption of pure science as opposed to appropriate technology as provided for by the extensionists in aligned ministries has added to the erosion of this once rich culture.

Cultural values have been fading slowly due to the emergence of climate change and its effects. As a result, there has been a tremendous loss in cultural species, cultural forests and the indigenous knowledge in the management of forests. It is therefore important to bring back indigenous knowledge to manage the continually fading indigenous species. As a result of the loss of indigenous species, owing to domestic and industrial use, the
environment has been impacted negatively. The process of reviving some species, particularly trees, to their normal status will take time due to the long period in which the species mature. Initiatives such as farm forestry are being encouraged by the government and are geared towards reducing the pressure on the existing forests. Most of the communities do not appreciate the use of exotic species, hence their poor adoption. The traditional and cultural forests are being co-managed by the locals (Kaya) and the KFS. The current state of the forest is based on sensitization to help in the conservation that will help in yielding future values to the community and the world at large. Most exotic species e.g. casuarinas and eucalyptus, are slowly replacing the indigenous species and some native species like *Afzelia* are slowly disappearing as the climate changes.

Traditional knowledge systems have helped the indigenous communities to cope with the climate change that has and is continuing to bring negative impacts to people and communities, especially those in the rural areas. The government should encourage the community members to keep to the traditional knowledge systems which will enable them to cope with the climate changes which are now threatening societies everywhere. The information systems should also be preserved so as to help the next generation with climate change mitigation skills.

**Acronyms and Abbreviations**

TK – Traditional Knowledge  
ILCs – Indigenous Local Communities  
IK – Indigenous Knowledge  
KFS – Kenya Forest Service  
KENRICK – Kenya Resource Centre for Indigenous Knowledge  
NMK – National Museums of Kenya  
KARI – Kenya Agricultural Research Institute  
WWF – World Wildlife Foundation  
UNESCO – United Nations Educational, Scientific and Cultural Organizations  
ICPAC – International Climate Prediction and Applications Centre
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Contributors’ Information
Roxventa A. Ongugo, and Samuel Kimani, Kenyatta University, Nairobi, Kenya.
THEME 2
African Indigenous Knowledge Systems (AIKS), Food Security and Health in Climate Change
Using the Knowledge of Organic Farming in Addressing Challenges from Climate Change

Eliud Magu Mutitu
University of Pannonia Georgikon Faculty,
Institute for Plant Protection, Keszthely, Hungary

John N. Wanjau
Kenya Institute of Organic Farming (KIOF), Juja, Kenya

Abstract
Organic farming is a system that relies largely on locally available resources and is dependent upon maintaining ecological balances and developing biological processes to their optimum. Western emphasis on mono-cropping introduced non-native foods (pineapple, cabbage, spinach, carrots, etc.) which required extensive irrigation and frequent applications of pesticides and chemical fertilizers. In Kenya this is a non-sustainable form of agriculture, given the fact that 80 percent of crops are grown in the arid lowlands, where rain is becoming increasingly unreliable. Long-term solutions to global warming, drought and crop failure must be addressed by reducing dependence on Western-style agriculture in favour of indigenous crops.

Any comprehensive strategy for addressing climate change must include both adaptation and mitigation, and organic farming has the potential to do both. Resilience to climate disasters is closely linked to farm biodiversity; practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. Farming practices that preserve soil fertility and maintain or increase organic matter, such as crop rotation, composting, green manures and cover crops, can reduce the negative effects of drought while increasing
productivity (FiBL 2007). In particular, the water-holding capacity of soil is enhanced by practices that depend on organic matter, helping farmers withstand drought.

Agriculture has the potential to change from being one of the largest greenhouse gas emitters to a much smaller emitter and even a net carbon sink. Organic systems have been found to sequester more carbon dioxide than conventional farms, while techniques that reduce soil erosion convert carbon losses into gains (Niggli et al. 2009).

**Keywords:** Organic Farming, organic systems, global warming, biodiversity

**Introduction**

Organic farmers’ knowledge can be understood as indigenous knowledge – local knowledge that is closely tied to sustainable ways of life. Such knowledge is vital to individual health, community resilience, national food security and overall sustainability. Organic farmers are a clearly defined community, set apart from other farmers by the certification process they must undertake. They depend on older forms of knowledge such as traditional farming practices to understand how farming was carried out before the introduction of chemical agriculture. They also depend on newer forms of knowledge, produced by both organic farmers and a fledgling number of researchers in university settings, to understand how to more fully address current, complex problems.

By UNESCO criteria, organic farmers’ knowledge would qualify as indigenous knowledge. As lifelong learners, organic farmers have ‘learned their way out’ of unsustainable farming practices and ‘learned their way in’ to more sustainable ways of life. Their indigenous knowledge systems have emerged from years of practice and critical reflection on how best to farm in nature’s image, favouring on-farm resources and not depending on costly, and destructive, purchased inputs.

Organic agriculture (OA), as an adaptation strategy to climate change and variability, is a concrete and promising option for rural communities and has additional potential as a mitigation strategy. Adaptation and mitigation based on organic agriculture can build on well-established practice because organic agriculture is a sustainable livelihood strategy with decades of use in several climate zones and under a wide range of specific local conditions. The financial requirements of organic agriculture as an
adaptation or mitigation strategy are low. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. Furthermore, OA has a recognized potential as a development strategy for rural communities.

OA as a mitigation strategy addresses both emissions avoidance and carbon sequestration. The first is achieved through: lower N\(_2\)O emissions (due to lower nitrogen input). It is usually assumed that 1-2 percent of the nitrogen applied to farming systems is emitted as N\(_2\)O, irrespective of the form of the nitrogen input. The default value currently used by the IPCC is 1.25\%, but newer research finds considerably lower values, such as for semi-arid areas (e.g., Barton et al. 2008). Secondly, there is less CO\(_2\) emissions through erosion management (due to better soil structure and more plant cover) because there usually is less erosion in organic farming systems than in conventional ones.

**Reducing Direct and Indirect Energy Use in Agriculture with OA**

There is no doubt that organic agricultural practices can provide synergistic benefits that include mitigating climate change. As stated in the 2002 report of the United Nations Food and Agriculture Organisation (FAO), organic agriculture enables ecosystems to better adjust to the effects of climate change and has major potential for reducing agricultural greenhouse gas emissions. The FAO had already estimated that organic agriculture is likely to emit less nitrous oxide (N\(_2\)O). This is due to lower N inputs, less N from organic manure from lower livestock densities; higher carbon/nitrogen (C/N) ratios of applied organic manure giving less readily available mineral N in the soil as a source of denitrification; and efficient uptake of mobile N in soils by using cover crops.

The FAO report found that, ‘organic agriculture performs better than conventional agriculture on a per hectare scale, both with respect to direct energy consumption (fuel and oil) and indirect consumption (synthetic fertilizers and pesticides)’, with high efficiency of energy use. Most of the energy input is indirect, and comes from the energy spent to manufacture and transport fertilizers, pesticides, farm machinery, animal feed and drugs. Nitrogen fertiliser is the single most energy-intensive input, accounting for
53.7% of the total energy use. Organic farming is more energy efficient mainly because it does not use chemical fertilizers.

**Use of Indigenous Knowledge Systems in Organic Agriculture**

Organic farming advocates a wide range of climate adaptation measures and coping strategies of rural and indigenous communities, including landscape restoration, changes in cropping systems, cultivation of stress-tolerant crops, organic agriculture, changes in livestock and fisheries management, indigenous beekeeping, biodiversity management, diet diversification, and soil and water management. Often, these strategies are the elements of integrated and site-specific approaches based on the indigenous and local knowledge and innovation.

**Soil Fertility Management**

Organic agriculture helps to counteract climate change by restoring soil organic matter content as well as reducing soil erosion and improving soil physical structure. It diversifies soil-food webs and helps cycle more nitrogen from biological sources within the soil. Organic agriculture practices that preserve soil fertility and maintain or increase organic matter – such as crop rotation, composting, green manures and cover crops reduce the negative effects of drought while increasing productivity. Organic agriculture is also self-sufficient in nitrogen due to recycling of manures from livestock and crop residues via composting, as well as planting of leguminous crops (Ensor & Berger 2009).

The evidence for increased carbon sequestration in organic soils seems clear. Organic matter is restored through the addition of manures, compost, mulches and cover crops. It is estimated that up to 4 tons of CO₂ could be sequestered per hectare of organic soils each year.

**Water Conservation and Harvesting Practices**

Important elements in response of communities to climate change within agricultural ecosystems include water and soil management practices such as improved water-retention practices in dry environments. Water-harvesting practices allow farmers to rely on stored water during droughts, or to increase water availability. For example, Kenya Institute of Organic Farming
(KIOF), a pioneer organization of organic farming in Kenya, has been training on old water harvesting system known as ‘zai’. The zai are pits that farmers dig in rock-hard barren land, into which water would otherwise not penetrate. The pits are filled with organic matter and attract termites, which dig channels and thus improve soil structure so that more water can infiltrate and be held in the soil. Other practices include fertility trench and basket compost that harvests water. Organic soils also have better water-holding capacity, which explains why organic production is much more resistant to climate extremes such as droughts and floods, and water conservation and management through agriculture will be an increasingly important part of mitigating climate change.

**Drought-tolerant Disease- and Pest-resistant Local Varieties**

Many farmers cope with climate change in various ways: minimising crop failure through increased use of drought-tolerant or disease- and pest-resistant local varieties, water-harvesting, mixed cropping, agroforestry, opportunistic weeding and wild plant gathering. These coping mechanisms not only help meet farmers’ subsistence needs, but also encourage biodiversity conservation. To offset crop failure arising from rainfall variability and unpredictability, farmers cultivate hardier (or drought-tolerant) types of the same crop species.

**Farm Biodiversity**

Resilience to climate disasters is closely linked to farm biodiversity; practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. Thus, farmers who increase interspecific diversity suffer less damage compared to conventional farmers planting monocultures (Borron 2006; Ensor & Berger 2009). OA integrates livestock which includes ruminants and non-ruminants as well as small animals such as poultry and apiculture. Moreover, the use of intraspecific diversity (different cultivars of the same crop) is insurance against future environmental change. Diverse agro-ecosystems can also adapt to new pests or increased pest numbers (Ensor & Berger 2009). Traditional agricultural varieties commonly remain an essential part of adaptation strategies.
Natural and Ecological Pest Control
Using natural pest and disease control is often cheaper than applying chemical pesticides because natural methods do not require buying expensive materials from the outside. Products and materials which are already in the home and around the farm are most often used. There is much concern over the dangers of chemical products. OA involves the use of plant extracts and physical and cultural controls which employ the wealth of indigenous knowledge in managing pest problem in crops. Farmers report little incidence of insect pest attack on traditional vegetables compared with exotic ones. Certainly, Crotalaria, Ochroleuca, Gynandropsis gynandra and Solanum nigrum all have a bitter taste and a strong smell. This suggests that these vegetables may repel some pests.

Adaptive Capacities to Climate Change in the Traditional Livestock System Based on IK
Organic farms attempt to provide animals with ‘natural’ living conditions and feed. Sustainably exploiting the IK bases that already exist among the traditional farmers is one sure method for them to adapt to climate change and uphold the livelihoods of communities. Studies have established the potential of IK and have inventoried the useful indigenous plants that have either medicinal or pesticidal properties (Elder 2010).

*Tephrosia vogelii* is an example of leguminous shrub mostly found in the tropical countries and contains rotenone, an important non-residue insecticide. The *in vitro* studies carried out validated the efficacy of *T. vogelli* to major tick vectors that have been responsible for the transmission of economically important tick-borne diseases like theilerioses. Farmers readily appreciate the cost effectiveness and sustainability of the plant materials. The values being realised from promotion and utilization of medicinal plants are expected to generate additional interest which will translate into more applications of IKs for various livestock management practices in relation to creating resilience and adaptation to climate change.

Indigenous Crops
Long-term solutions to global warming, drought and crop failure must be addressed by reducing dependence on Western-style agriculture in favour of
indigenous crops. Western emphasis on mono-cropping introduced non-native foods (pineapple, cabbage, spinach, carrots, etc.) which required extensive irrigation and frequent applications of pesticides and chemical fertilizers. Traditional crops and varieties, which are better adapted to local environmental conditions, are more stable in their yield. Traditional crops and varieties also tend to have fewer disease problems. Kenya Institute of Organic Farming (KIOF) emphasizes to farmers the importance of growing both traditional crops such as sorghum, millet, cassava, yams, arrow root, banana and a variety of indigenous vegetables, among them *Gynadropsis gynandra*, *Solanum nigrum*, *Vigna unguiculata*, *Amaranthus* sp. and *Cucurbita maxima* (Nehemia 2010).

Table 1. Types of traditional African vegetables identified during a market survey at Kakamega, Kenya

<table>
<thead>
<tr>
<th>English</th>
<th>Botanical name</th>
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<tbody>
<tr>
<td>amaranth</td>
<td><em>Amaranthus</em> sp.</td>
</tr>
<tr>
<td>cowpeas</td>
<td><em>Vigna</em> sp.</td>
</tr>
<tr>
<td>pumpkin leaves</td>
<td><em>Cucurbita</em> sp.</td>
</tr>
<tr>
<td>black nightshade</td>
<td><em>Solanum nigrum</em></td>
</tr>
<tr>
<td>sunnhemp</td>
<td><em>Crotalaria brevidens</em></td>
</tr>
<tr>
<td>jute plant</td>
<td><em>Corchorus olitorius</em></td>
</tr>
<tr>
<td>pig weed</td>
<td><em>Amaranthus</em> sp.</td>
</tr>
<tr>
<td>spider plant</td>
<td><em>Gynadropsis gynandra</em></td>
</tr>
</tbody>
</table>

(Nekesa & Meso 2011)

Table 2. Total mitigating potential of organic sustainable food systems

<table>
<thead>
<tr>
<th>Global potential of organic sustainable food systems for mitigating climate change</th>
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<tbody>
<tr>
<td>Greenhouse gas emissions</td>
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<tr>
<td>Carbon sequestration in organic soil</td>
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<tr>
<td>Localising food systems</td>
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</tbody>
</table>
The total mitigating potential of organic sustainable food systems is 29.5% of global ghg emissions and 16.5% of energy use, the largest components coming from carbon sequestration and reduced transport from relocalising food systems (AgroEco 2006).

**Conclusion**

Organic agriculture, as an adaptation strategy to climate change and variability, is a concrete and promising option for rural communities and has additional potential as a mitigation strategy. Adaptation and mitigation based on organic agriculture can build on well-established practice because organic agriculture is a sustainable livelihood strategy with decades of use in several climate zones and under a wide range of specific local conditions. The financial requirements of organic agriculture as an adaptation or mitigation strategy are low. Use of traditional crop and livestock species and varieties, with new materials where necessary, has been a common feature.

Benefits include: the resilience of local food systems and their adaptation to change can be enhanced through a strategy of diversification; ecosystem protection and restoration can reduce the adverse effects of climate change on local food systems; resilience and adaptability seem to be enhanced by the use of sustainable agricultural practices; maintenance of...
intra- and inter-species and access to new diversity are essential elements in improving adaptability and resilience.

The need to adapt to climate change has often led to the revival of traditional practices. The continuous process of innovation involves the use of traditional knowledge combined with access to new knowledge and adaptation solutions are local and often most relevant and effective when undertaken at community level. Combining IK with new scientific information is an important part of improving resilience and ensuring adaptability. New information may often be needed but it has to be placed in the context of a framework of traditional knowledge which itself is dynamic and continually developing.

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Contributors’ Information
Mr. Eliud Magu Mutitu, Institute of Plant Protection, 8360 Keszthely Festestic Str. Ut 5, Hungary

John. N. Wanjau, Kenya Institute of Organic Farming (KIOF), Juja, Kenya
Indigenous Traditional Knowledge Pastoral Adaptation Strategies to Climate Change in Selected Areas of the Cattle Corridor of Uganda

Henry Massa Makuma
Makerere University, Department of Agriculture and Environmental Sciences, Uganda

Abstract
Pastoralists’ communities have been able to use Indigenous Traditional Knowledge (ITK) to cope in various ways with climate change shocks. However, little is known of these ITK coping practices among pastoralists in Uganda. This study examined the major climatic shocks in the past three decades amongst agro-pastoralists and adaptation and ITK practices to the changes in climate in the cattle corridor of Uganda. Qualitative and quantitative data were collected mainly using individual and group discussions and interviews (individual, key resources persons). Quantitative data was analysed using Statistical Package for the Social Sciences. Qualitative data was subjected to development of emerging patterns and themes for analysis. The major climatic shocks identified were prolonged and increased frequency of dry spells, cattle disease outbreaks, especially foot and mouth disease and contagious Bovine Pleuro-pneumonia (CBPP) disease. In response to the prolonged dry spells, the pastoralists constructed communal wells and dams, moved from one place to another, reared local cattle breeds and made changes in (cattle) feeding times. The implications of movement were the increased spread of diseases and death of cattle. Coping strategies documented were migration to relatively safe areas, quarantine, vaccinations, use of herbs, native diagnosis and treatment of animals. The Indigenous Traditional Knowledge (ITKS) described were use of herbs, timing of feeding of animals and treatment. In conclusion, the pastoralists
have endeavoured to adapt, however, their adaptive capacity needs to be enhanced and supported. It is recommended that the ability of pastoralists to harvest, store and efficiently use water as they minimize disease spread needs to be enhanced.

**Keywords:** Dry spells, diseases, water, pastures, cattle

**Introduction**

Climate is the basis of the existence of all flora and fauna. Climate influences human activity and the reverse is equally true and thus the need to give it attention. Climate change means the fluctuation between the normally experienced climate conditions and a different, but recurrent, set of the climate conditions over a given region of the world (IPCC 1998). It also refers to a shift in climate occurring as a result of natural and/or human interference (Wigley 1999). Climate change has been fronted as one of the defining challenges for human development and ecological wellbeing in the 21st century (UNCTAD/WTO 2007; UNDP 2008). Sub-Saharan Africa, where Uganda lies too, is one of the regions most vulnerable to climate change (Slingo *et al.* 2005; Morton 2007; Thornton *et al.* 2006) because of the growing population, environmental degradation and poverty. There is a strong link between climate and livelihoods of communities in Uganda, an agro-based economy. This is because Uganda’s agricultural activities depend heavily on rain i.e. it is rain-fed agriculture. Dependence on rain for a living makes rural livelihoods and food security highly vulnerable to effects of climate variability. Part of the consequence has been unpredictable rain patterns which have changed and/or shifted growing season conditions (IPCC 2001). Engagement in production is turning out to be more of a trial and error game, though of late more losses due to rain failures and sometimes storms/floods have been experienced.

The importance of agriculture in Uganda cannot be ignored. The sector accounts for more than 50% of the country’s employment and export earnings, and contributes significantly to government revenues, up to 20% of total GDP (MAAIF/UBOS 2009). By 2008, there were about 6328000 heads of cattle, 6852000 goats and 1141000 sheep in Uganda (MAAIF/UBOS 2009) and these are largely concentrated in the cattle corridor. Any effects from climate change will directly affect agricultural activities in Uganda.
Currently, Uganda suffers from extremes of climate change i.e. floods and high atmospheric temperatures. Indeed, studies confirm that Africa has warmed 0.7°C over the 20th century and general circulation models project warming across Africa will range from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario) (Hulme et al. 2001; IPCC 2001). Therefore changes in climate will affect the production potential of pastoralism. However, survival instincts have made the pastoralists’ communities in Uganda more resilient and they have adapted to the changes that have occurred overtime.

Indigenous Traditional Knowledge (ITK) and Adaptation
Efforts to address climate change have so far focused on two response strategies: mitigation and adaptation (IPPC 2001). Adaptation aims to cope with the problem of climate impacts when they materialize. Adaptation is seen by many scientists and policymakers as a powerful option to reduce the negative impact of the climate change or take advantage of the positive effects. The prospect of adapting to significant climate change, however, remains challenging, with the uncertainty of the extent of this change a major limiting factor (Challinor et al. 2007). Pastoralists however, using ITK, have adapted to the effects of climate change in a number of ways.

For centuries, farmers have planned agricultural production and conserved natural resources by adopting indigenous knowledge. The development of indigenous knowledge systems, including management of natural environments, has been a matter of survival for the people who generate these systems. The systems are cumulative, representing generations of experience, careful observations and trial and error experiments (Berkes et al. 2000). ITK is knowledge that is unique to a given culture or society. It is in contrast to the knowledge gained at formal institutions. The development of indigenous knowledge systems, covering all aspects of life, including management of natural environment, has been a matter of survival for people who generated them (Mahoo 2011). Indigenous knowledge has made, and can still make, a significant contribution to resolving local problems but the adaptation practices used by pastoralists and documentation thereof has been limited. This study therefore examined the major climatic shocks in the past three decades and the ITK practices being used as adaptation strategies by the pastoralists to adapt to climate change effects.
Methodology

Description of the Study Area

This study was conducted among selected pastoral communities in Kiruhura and Luwero districts located along the cattle corridor of Uganda (see Figure 1). The corridor occupies a significant proportion of Uganda’s total land area of approximately 107 000 km² (44%) (RMPU1 2001). The cattle corridor stretches from the south through the districts of Ankole and northern parts of Buganda to the north-central part of Uganda, covering parts of Apac, Lira, Soroti districts, and up to Kotido, Kaabong, Nakapiripirit and Moroto districts in the northeast. These areas are generally semi-arid and are roamed by nomads particularly the traditional pastoralists, the Bahima in the southwest and the Karamojong in the northeast.

Figure 1: The corridor occupies a significant proportion of Uganda’s total land area of approximately 107 000 km² (44%) (RMPU1 2001)

The Uganda cattle corridor exhibits most of the characteristics of rangelands; low and erratic rainfall regimes leading to frequent and severe droughts, and fragile soils with weak structures which render them easily eroded. Pastoralism is the main economic activity and rangelands are traditionally used mainly as a common pool resource. Generally, the study area traverses an ecologically, ethnically and institutionally heterogeneous zone. It was selected to capture variation in ecological potential, market access, livestock mobility and ethnic diversity. The districts of Luwero and Kiruhura were
selected for the study because they exhibit the entire characteristics of the cattle corridor of Uganda. Furthermore, these districts are characterized by having a high concentration of cattle i.e. 79787 and 342315 respectively in the region (MAAIF/UBOS\(^2\) 2009).

Sampling Procedure and Data Collection
Two Sub-counties were selected purposely based on the highest number of cattle from the study area districts of Luwero and Kiruhura. In each district, two sub-counties of Kamira and Nyakashara were selected respectively. From the Sub-counties of Kamira and Nyakashashara, one parish was selected purposely because it had the highest number of pastoralists. From each parish, five villages were selected purposely, based on the highest number of pastoralists totalling up to ten villages. Ten pastoralists were selected from each village for individual interviews which brought the total to 100 respondents. From each sub-county, 15 pastoralists were invited for the focus group discussion (FGD) with up to three FGD in each sub-county, bringing the total to 90 participants. Both old (45+) and young (younger than 45 years) pastoralists were invited for the FGD. The respondents were either groups of people or individuals, most of them 30-75 years old, capable of reconstructing the major climatic shocks, ITK and adaptation history of the area, as pastoralists perceived it. Data was collected over a period of two years. An additional number of individual communications were also done with a number of village leaders and local administrative officers.

Data Analysis
Qualitative data obtained was subject to qualitative analysis procedures which enabled the highlighting of emerging patterns of themes according to Neuman (Neuman 2009). Quantitative data was entered into Epidata and exported to Statistical Package for to Social Sciences (SPSS). Version 16.0 was used to analyse the major climatic shocks and ITK adaptation strategies employed over time by generation of frequencies and percentages tables.

Conceptual Framework
Indigenous knowledge in this study refers to the body of knowledge which is native to the farmers and handed on through narrative. This knowledge
system is not exclusive however but can be modified with time. Modern knowledge refers to concepts, ideas, values and beliefs which are imparted to the natives by extension workers who are trained in scientific agriculture. It should be noted that in some cases the difference between ITK and modern techniques is not distinctive enough.

To a large extent, improved agricultural research improves on already existing techniques. For example, water harvesting and movement fall under both ITK and modern techniques of a pastoralist’s lifestyle. This study is premised on the realization that as humanity try to adapt to the environment in which we live and from which we derive our livelihood, we improve our knowledge, skills and strategies to harness natural resources such as climate in a sustainable manner. The knowledge and skills are derived from our daily interactions with environment, observations and experiments. These experiences greatly shape and model the decisions made by people regarding exploitation of resources. The knowledge, skills and practices relating to natural resources are passed down through the generations by way of cultural learning processes. It is the outcome of all these among different groups and the environment that is termed indigenous, local, tradition or people’s knowledge.

Findings and Discussions
The Major Climatic Shocks in the Past Three Decades
Frequent and prolonged dry spells (often referred to as drought) and increased cattle disease outbreaks were the major shocks that pastoralists experienced. The intensity of the shocks reportedly increased over time (reflecting on the last thirty years). The abnormally longer periods of absence of rain from November through March, coupled with high atmospheric temperatures did not only affect cattle production but also rendered water and grasses or pastures unavailable for the cattle. During the months of July to October, there are very minimal rains, often drizzles, yet scanty. This differs from the normal rainfall seasons of Uganda. Across much of Uganda the climate is bimodal, with two rainy seasons, the long rains starting in March and lasting through June, and the short rains running from around October/November until December/January. Furthermore, the swamps, which are known to be the major animal water points, dry up. Competition between herds and wild game, agricultural activities like irrigation and inadequate management of the water source also contributed to the drying of
the swamps. As a consequence of wild game and cattle sharing the same water points, the frequency of Contagious Bovine Pleuro-pneumonia (CBPP) and Foot and Mouth diseases (FMD) has reportedly increased, with FMD reported more frequently than CBPP.


Rainfall in the arid and semi-arid areas has always been unpredictable and has varied considerably over space and time, with occasional severe droughts. According to the climate analysis in the Ugandan Government’s National Adaptation Programmes of Action (NAPA), published in December 2007, the wetter areas of Uganda, around the Lake Victoria basin and in the east and northwest, are tending to become wetter. Meanwhile, the number of drought events is already on the increase, presenting 6-7 times in the just concluded decade compared to 1-3 times in each of the past decades (GoU 2007). Indeed this is true, as our findings indicate that recently there are increased and prolonged dry spells in the cattle corridor.

These increased dry spells have resulted in an increase of diseases. Parasites and pests thrive in warm periods and their reproduction rates are
always accelerated during this time. Because the pastoralists tend to move their animals during the dry spells, diseases are spread from one place to another. Besides, practices such as communal watering and grazing of animals fuel the transference of diseases from one animal to another. Furthermore, the interaction of wild animals and domestic animals has been noted to lead to the exchange of diseases and most often these are zoonotic in nature.

CBPP and FMD are state-controlled animal diseases in Uganda and are grouped under the notifiable animal diseases. FMD, Rinderpest (RP) and CBPP are all among the world’s most important trans-boundary animal diseases. It has been documented that over 80% of the TADs occur in Sub-Saharan Africa, with over 60% of the most important TADs in the world having occurred or currently present in Uganda.

**Adaptation to the Climatic Shocks**

Pastoralists have learnt to co-exist with the situation to their benefit. They have developed ways (strategies) to minimize the intensity of the effects of adapting to the major shocks using various ITK methods. The most common strategy to water scarcity was/ is construction of water dams, which are used communally.

**ITK Use in Pastoralism in Adapting to Prolonged Dry Spells and Diseases**

In harvesting water, the pastoralists have improvised gutters that they place on the roof of the house to trap water. They then build tanks and store the water. This water helps in watering the animals during the dry spells and also in domestic use.

They have the ability to detect the seasonal changes using insects. The insects they said to be using to predict the seasons are termites and white ants. They said when the white ants appear, it is an indicator that the rains are going to come soon.

Pastoralists practice selection of good animals as in the case of formal breeding programmes to control diseases and maximize outcomes. Further still, they select breeds that can withstand the harsh conditions of the climatic shocks. The factors they consider in selection of the animals are
based on the past production abilities of meat, milk, ability to withstand diseases and cope with the dry spell.

**Burning of Pasturelands**
The pastoralists burn the pasturelands when the grass becomes dry. Essentially, the pastoralist said that ash is a source of nutrients which is rightly so as ash is rich in potassium. So this way, they improve on the quality of the pastures that grow after burning. Burning also was said to deal with weeds and invasive species such as *Latana camara* that reduces the quality of pastures as cattle do not like to feed on them.

**Feeding Timing**
Pastoralists reported feeding the animals very early in the morning. This was because during the morning hours, the pasture has dew on it. The pastures are also said to be palatable to the animals at this time. This practice goes a long way to reduce the water and pasture requirements of the animals throughout the day. Further, the animals spend most of the day satisfied.

The pastoralists also said in event of dry spells, they keep more than one type of livestock. This was premised on the notion that putting all your eggs in one basket is not good. Different animals kept were cattle, goats, sheep and poultry.

Pastoralists use their hands to help animals experiencing difficulty in calving to deliver. In case the cow fails to release the placenta, the pastoralists give the animals crushed cow peas leaves in water. Furthermore, it was reported that hitting the bottom of the cow is believed to aid the animal in releasing the placenta. They also give the animals a mixture of *Basella alba*, water and salt to aid in releasing the placenta. In case of failure in calving, the cow is tied near a fire, presumably to burn the fats believed to be blocking the delivery.

Worms in animals were reported to be treated using green vegetables with specific measure, while diarrhea is treated using a mixture of cowpea leaves and little salt. The mixture maybe boiled or not. Fresh *Cannabis sp* leaves and salt are mashed and added to treat animals suffering from fever, cough and poor appetite and diarrhea.

In treating fever in cattle, the pastoralists said they make concoctions
of *Vernonia sp* and give it to the animals. They also gave fresh piggery urine to the animals, saying this treats the fever.

To increase milk production, farmers add salt to banana peels and *omubimba* (*Sesbania*) leaves are squeezed with salt and a little water and fed to the animals.

To make kraals comfortable for livestock; pastoralists regularly make a fire in the kraal to kill any pests. They also fallow the kraals to reduce pest infestations, especially of ticks. They also reported piercing fleas with a sharp object such as a needle. These fleas eventually die. They burnt dry cow dung to repel insects from the animals as apparently this works like the application of insecticides to repel insects.

**Implications of the Use of ITK to Adapt by the Pastoralists**

The study revealed that there is a diversity of local and customary practices for climate change adaptation. These include multiple species management and resource rotation. The social mechanisms behind these traditional practices include a number of adaptations for the generation, accumulation and transmission of knowledge. Similarly, Berkes *et al.* (2000) found out in their study that some traditional knowledge and management systems were characterized by the use of local ecological knowledge to interpret and respond to feedbacks from the environment to guide the direction of resource management. These traditional systems had certain similarities to adaptive management with its emphasis on feedback learning in its treatment of uncertainty and unpredictability intrinsic to all ecosystems.

Despite the increased influence of modernization and economic changes, a few traditional agricultural management and knowledge systems are still predominant. These systems exhibit important elements of sustainability. In this case, they are well adapted to a particular environment, rely on local resources, are small scale and decentralized, and they tend to conserve the natural environment. Many pastoralists felt that the use of ITK must be promoted in the communities. This enhances the sharing of knowledge from those who do not know to those who know and vice-versa. Pastoralists appreciate the importance of ITK and integration with modern techniques will go a long way in enabling them to adapt more ably to the shocks of climate change. Huntington (2000) agrees that the way such knowledge is being organized and culturally embedded, its relationship to
institutionalized, professional science and its role in catalysing new ways of managing environmental resources has become of paramount importance.

It is important to note that a lot of ITK is lost through the death of elderly people because there is no formal documentation of this knowledge. Besides, some people do not feel free to share their knowledge. This is because of the fear of losing communal property rights. Having a form of documentation of these will go a long way in using these ITKs from one generation to another. This can also be enhanced to come up with best practices and procedures. Protecting the property rights of the pastoralists also needs to be looked into (Fabricius & Koch 2004). The Rio de Janeiro convention on biodiversity emphasizes the equitable sharing of proceeds and benefits accruing from the local people’s knowledge and genetic diversity.

Conclusions and Recommendation
The most important shock that have affected the pastoralists in the past three decades is the increased frequency of prolonged dry spells that have resulted in the absence of water and pastures and the increased incidences of disease epidemics. A number of ITK practices have been employed to adapt to the shocks but there is no formal documentation of these.

Therefore the study recommends that the ability of pastoralists to harvest, store and efficiently use water as they minimize disease spread needs to be enhanced. Also undertaking an inventory/documentation of the ITKs that have been used over the years needs to be done to enhance the pastoralists’ adaptation to the effects of climate change.

References


Contributor information
Henry Massa Makuma, Department of Agriculture and Environmental Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda
Tel: +256-782339411/ + 256-702846765
E-mail: henrimassa@yahoo.com or: massahenri@gmail.com
Abstract
Organic farming has been practiced in Africa for centuries as an indigenous environmental conservation and climate change adaptation and mitigation strategy. African local communities using their tested local knowledge, skills and experience know that organic farming has the potential to address the combined threat of climate change and other environmental stresses. It promotes the use of cultural, biological and mechanical methods as opposed to using synthetic materials. However, this community-based knowledge is tied to specific climatic conditions and cannot be transferred to other areas without due caution and modification including further research. Its success also requires a wider recognition among institutions that currently promote mainly conventional agriculture.

Keywords: Organic farming, climate change, indigenous knowledge

Introduction
The Fourth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC) (2007) states that a wide range of adaptation options are
available and are required to reduce community vulnerability to climate change which possesses considerable threat to agricultural communities in Africa. The majority of the people depend on it for their living. The threat includes the likely increase of extreme weather conditions, water stress, drought and desertification, as well as adverse health effects due to extreme heat and increased spread of infectious diseases, such as malaria. Adverse effects are likely to multiply if adaptation efforts fail. This may then overstretch many societies’ adaptive capacities, which may lead to destabilization and security risks, including loss of livelihoods, malnutrition, forced migration and conflicts (Lobell et al. 2008). The Bali Action Plan from the UN Climate Change conference in Bali in 2007 (UNFCCC 2007) clearly emphasizes the importance of enhanced action on adaptation. Indigenous African communities have for centuries developed various strategies of adapting to climate change to ensure food security.

Ludwig and Pavel (2009) state that adaptation to global warming and climate change is a response that seeks to reduce the vulnerability of natural and human systems to the effects. They argue that even if emissions are stabilized relatively soon, climate change and its effects will last many years and adaptation will be necessary. Climate change adaptation is especially important in African and other poor developing countries since those countries are predicted to bear the heavy brunt of the effects of climate change. In other words, the capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations, and most African countries generally have less capacity to adapt (Schneider 2007). Adaptive capacity is closely linked to the level of social and economic development of a country (IPCC 2007). The ability of human systems to adapt to and cope with climate change depends on such factors as wealth, technology, education, infrastructure, access to resources, management capabilities, acceptance of the existence of climate change and the consequent need for action, and socio-political will. Populations and communities are highly variable in their endowments of these attributes, with African countries being among those worst placed to adapt to global warming.

The United Nations defines mitigation in the context of climate change as a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes and electricity generation, switching to renewable energy
(solar or wind), and expanding forests and other ‘sinks’ to remove greater amounts of carbon dioxide from the atmosphere.

Rosenzweig and Tubiello (2007) and IPCC (2007) reveal that adaptation entered the climate change agenda more prominently only recently, while mitigation has been a topic for a long time. This is reflected in the fact that there is more research available on organic farming as mitigation than as an adaptation strategy (Niggli et al. 2008). However, the IPCC Working Group II (2007) argues that mitigation and adaptation should be complementary components of a response strategy. Their report makes the following observations:

1. Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts; and
2. Those with the least resources have the least capacity to adapt and are the most vulnerable.

Adaptation, sustainable development and enhancement of equity can all be mutually reinforcing. One of the community-based strategies in Africa to climate change adaptation and mitigation is the practice of organic farming discussed in detail in the following sections.

**Methodology**

The study on Organic Farming as an Indigenous African Climate Change Adaptation Strategy was based on the examination of secondary sources. According to Kragh (1999) in research a secondary source is a document or recording that relates or discusses information originally presented elsewhere. A secondary source contrasts with a primary source, which is an original source of the information being discussed. Secondary sources involve generalization, analysis, synthesis, interpretation or evaluation of the original information. The secondary data can be internal or external to the organization and accessed through the internet or a perusal of recorded or published information. This study used relevant sources of secondary data, including books and periodicals, and government and non-governmental publications related to the research problem. Taking into consideration the comprehensive nature of the study, the consultation of secondary data has the following advantages: appropriate and adequate secondary data to draw
conclusions from were readily available. It was far cheaper in this case to collect secondary data than to obtain primary data; the time involved in searching secondary sources was much less than that needed to complete primary data collection. The following section presents and discusses the findings.

The Nature and Characteristics of Organic Farming

According to UNDP (2008) and Borron (2006), organic farming is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account the view that regional conditions require locally adapted systems. This is achieved by using, where possible, cultural, biological and mechanical methods, as opposed to synthetic materials, to fulfil any specific function within the system. An organic production system is designed to: (i) enhance biological diversity within the whole system; (ii) increase soil biological activity; (iii) maintain long-term soil fertility; (iv) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources; (v) rely on renewable resources in locally organized agricultural systems; (vi) promote the healthy use of soil, water, air, as well as minimize all forms of pollution that may result from agricultural practices.

Eyhorn (2007) rightfully states that organic farming is not only a specific agricultural production system. It is also a systemic and all-encompassing approach to sustainable livelihoods in general, where due account is given to relevant factors of influence for sustainable development and vulnerability, be this on physical, economic, or socio-cultural levels. In the African indigenous knowledge context, organic agriculture has a long tradition as a farming system and it has been adapted for many climate zones and local conditions by most African farming communities.

In their discussion of organic agriculture, Niggli et al. (2007) indicate that organic agriculture avoids nutrient exploitation and increases soil organic matter content. In consequence, soils under organic farming capture and store more water than soils under conventional cultivation. Production in organic agricultural systems is thus less prone to extreme weather conditions, such as drought, flooding and water logging. Organic
farming accordingly addresses key consequences of climate change, that is, increased occurrence of extreme weather events, increased water stress and drought, and problems related to soil quality (IPCC 2007).

Furthermore, African farmers have over the years realized that organic farming reduces the vulnerability to climate change and variability due to a number of factors. First, it comprises highly diverse farming systems and thus increases people’s diversity of income sources and their flexibility to cope with adverse effects, such as changed rainfall patterns. This leads to higher economic and ecological stability through optimized ecological balance and risk spreading. Second, organic farming is a low-risk farming strategy with reduced input costs and, therefore, lower risks in the case of partial or total crop failure due to extreme weather events or changed conditions in the wake of climate change and variability (El-Hage Scialabba).

As such, it is a viable alternative for poor farmers as higher farm incomes are thus possible due to lower input costs and higher sale prices. The coping capacity of the farms is increased and the risk of indebtedness is lowered. Risk management, risk-reduction strategies and economic diversification to build resilience are also prominent aspects of adaptation, as mentioned in the Bali Action Plan (UNFCCC 2007).

Badgley et al. (2007) show that crops and crop varieties used in organic farming are usually well adapted to the local environment. Local effects of climate variability cannot be foreseen in detail because, on the local level, climate change models are not very accurate or even available. Adaptation thus may utilize measures that build on self-adaptive capacity, such as local crop breeding. The systemic character (on farm breeding, etc.) of organic agriculture is especially adequate to provide such. Notwithstanding this potential, more research is needed on how organic farming systems perform under increased disease and pest pressures, which are important effects of climate change on agriculture (IPCC 2007), and on how local crop varieties adapt to climate change and variability. Organic farming also seems to perform better than conventional agriculture under water constraints.

Eyhorn (2007) states that by its nature, organic farming is an adaptation strategy that can be targeted at improving the livelihoods of rural African populations and those parts of African societies that are especially vulnerable to the adverse effects of climate change, variability and improvements via reduced financial risk, reduced indebtedness and increased
diversity. Furthermore, by its systemic character, organic farming is an integrative approach to adaptation, with the potential also to work toward the United Nations Millennium Development Goals, in particular Goal 1 (‘eradicate extreme poverty’) and Goal 7 (‘ensure environmental sustainability’). The pivotal role agriculture plays in achievement of these goals and the challenges climate change poses to this task are widely acknowledged (DFID 2005). Slater et al. (2007) show that organic farming addresses many of the key challenges identified for adaptation to climate change and variability and it fulfils many of the criteria, which are seen as important general prerequisites for such strategies. Organic farming as a mitigation strategy addresses both emissions avoidance and carbon sequestration. The first is achieved through:

- Lower N₂O emissions (due to lower nitrogen input): It is usually assumed that 1-2% of the nitrogen applied to farming systems is emitted as N₂O irrespective of the form of the nitrogen input. The default value currently used by the IPCC is 1.25%, but newer research finds considerably lower values, such as for semi-arid areas (Barton et al. 2008);
- Less CO₂ emissions through erosion (due to better soil structure and more plant cover): There is usually less erosion in organic farming systems than in conventional ones. The effect of erosion on CO₂ emissions is still controversial (cf. IPCC 2007; and Lal et al. 2004); and
- Lower CO₂ emissions from farming system inputs (pesticides and fertilizers produced using fossil fuel).

Niggli et al. (2008) argue that the effects of animal husbandry on mitigation in organic agriculture also need to be assessed. Animal manure is often of particular importance to organic farms, but livestock is also an important source of greenhouse gases. Soil carbon sequestration is enhanced through agricultural management practices (such as increased application of organic manures, use of intercrops and green manures, higher shares of perennial grasslands and trees or hedges, etc.), which promote greater soil organic matter (and thus soil organic carbon) content and improve soil structure (IFOAM 2008). Increasing soil organic carbon in agricultural systems has also been pointed out as an important mitigation option. Very rough
estimates for the global mitigation potential of organic agriculture amount to 3.5-4.8 Gt CO\textsubscript{2} from carbon sequestration (around 55-80\% of total global greenhouse gas emissions from agriculture) and a reduction of N\textsubscript{2}O by two-thirds (Niggli \textit{et al.} 2008). For sound estimates, however, more information on the mitigation potential of organic farming – duly differentiated according to climatic zones, local climatic conditions, soil characteristics, variations in crops and cultivation practices, etc. – is still needed.

**Organic Farming in Africa**

Belfrage (2004) argues that African farming systems are characterized by very low level of input use and the low take-up of green revolution technologies. Hence, it is sometimes claimed that most agriculture in Africa is already de facto organic. This is because of the unsustainable way in which indigenous African agriculture, which is predominantly subsistence-based, becomes partially commercialized, but the system evidently fails to meet food security needs or to protect fragile environments. However, where conversion to organic farming has been fully achieved, economic and viable yields are attained. This is in stark contrast to the experience in the Western countries where conversion to organic farming usually leads to a loss in yields (at least in the first years). IFOAM (2004) indicates that organic farming is showing itself to be a viable sustainable development option for Africa. Therefore, promoting organic farming in Africa does not mean a return to some form of low technology, backward or traditional agriculture – but involves pursuing a blend of innovations originating from a participatory intervention involving scientists and farmers.

The organic farming system emphasizes management over technology and biological relations and natural processes over chemically intensive methods (IFOAM 2004). Within this context, Halberg \textit{et al.} (2006) rightly states that organic farming in Africa must be viewed beyond the perspective of providing commodities for the global market. Rather it should be seen as an agricultural system that enhances and manages the complexity of the ecosystem rather than reducing and simplifying the biophysical interactions on which agricultural production depends. It consciously integrates and takes advantage of naturally occurring beneficial interactions and the rich layers of indigenous knowledge. But most importantly, organic farming in Africa must be seen as a process of learning and adaptation, which results in meeting household objectives for sustainable and adequate
food production and increases environmental resilience and social capacity. In recent years some policy makers and donors have started to recognize the potential of export-oriented organic farming as a means of generating foreign exchange and increasing incomes. Yet the broader benefits of organic farming and agro-ecology (in terms of enhancing food security, environmental sustainability and social inclusion and reducing exposure to toxic pesticides) often go unrecognized or are simply ignored. Furthermore, promoters of modern technologies, such as genetically modified organisms (GMOs) view Africa as a virgin and receptive market. These technologies are being enticingly packaged and sold to African countries as modernizing agricultural development programs (Smit & Skinner 2002). However, with the growth of the organic farming sub-sector, these packages are being more carefully scrutinized by some African countries, some of whom are rejecting them.

There are two levels of organic farming in Africa, certified organic production and non-certified or agro-ecological farming (Prowse & Brownholtz-Speigt 2007). Certified production is mostly geared to products destined for export beyond Africa’s shores. However, local markets for certified organic products are growing, especially in Egypt, South Africa, Uganda, Kenya and Tanzania. Statistics reveal that with few exceptions (notably Uganda), certified organic farming is relatively underdeveloped in Africa, even in comparison to other low-income continents. Organic certification is mainly organized under participatory guarantee systems that are guided by an Internal Control System operated by a farmers’ group linked to an exporter, who holds the organic certificate.

Bizikova et al. (2007) states that certified organic production represents only the tip of the iceberg of organic farming in Africa, and evidence is emerging of a far larger agro-ecological movement in various parts of Africa. Local NGOs and farmers’ groups as well as development agencies are increasingly adopting organic techniques as a method of improving productivity and addressing the very pressing problems of food security. Agro-ecological approaches also address a number of other priority concerns. They resonate with and are being used in initiatives designed to:

- ensure food security;
- eradicate poverty;
- maintain and enhance soil fertility;
- combat desertification;
• promote tree-planting and agro forestry;
• develop low and no input means of combating pests;
• promote the use of local seed varieties;
• maintain and enhance biodiversity;
• support the most vulnerable social groups (particularly women and women-headed households); and
• combat global warming.

To date, research to track the extent to which these approaches are being employed on the ground, or their effectiveness, vis-à-vis other approaches, in meeting economic, social and environmental objectives, is very limited. Yet there is growing evidence that their appeal is increasing and often proving highly successful in meeting these aims.

**The Challenge of Markets for African Organic Farming Products**

It emerges that with a few exceptions (notably Egypt and South Africa) the African market for organic produce is very small. This is due to lack of awareness, low-income levels, lack of local organic standards and other infrastructure for local market certification (Kalibwani 2004). Therefore, most certified organic production in Africa is geared towards export markets, with the large majority being exported to the European Union, which is Africa’s largest market for agricultural produce (and the world’s largest organic market). The range of certified organic products currently being produced in Africa is shown in the Table 1.

**Table 1: Organic Produce from Africa (By Type and Country)**

<table>
<thead>
<tr>
<th>Product Group</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Vegetables</td>
<td>Egypt, Kenya, Madagascar, Malawi, Morocco, South Africa, Tunisia, Uganda, Zambia</td>
</tr>
<tr>
<td>Bananas</td>
<td>Cameroon, Ghana, Senegal, Uganda</td>
</tr>
<tr>
<td>Citrus Fruits, Grapes (including wine)</td>
<td>Egypt, Morocco, South Africa</td>
</tr>
<tr>
<td>Tropical fruits (fresh) Avocados, Mangos,</td>
<td>Cameroon, Egypt, Ghana, Madagascar, Senegal, South Africa, Tanzania, Uganda</td>
</tr>
</tbody>
</table>
## Pineapples, Papaya

<table>
<thead>
<tr>
<th>Dried Fruits</th>
<th>Algeria, Burkina Faso, Egypt, Madagascar, Morocco, Tanzania, Tunisia, Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>Cameroon, Ethiopia, Kenya, Madagascar, Tanzania, Uganda</td>
</tr>
<tr>
<td>Tea</td>
<td>Tanzania, Uganda</td>
</tr>
<tr>
<td>Cocoa</td>
<td>Cameroon, Ghana, Madagascar, Tanzania, Uganda</td>
</tr>
<tr>
<td>Sugar</td>
<td>Madagascar, Mauritius</td>
</tr>
<tr>
<td>Cotton</td>
<td>Benin, Egypt, Senegal, Tanzania, Uganda</td>
</tr>
<tr>
<td>Coconut Oil</td>
<td>Mozambique</td>
</tr>
<tr>
<td>Palm Oil</td>
<td>Ghana, Madagascar, Tanzania</td>
</tr>
<tr>
<td>Olive</td>
<td>Tunisia</td>
</tr>
<tr>
<td>Ground Nuts (peanuts)</td>
<td>Zambia</td>
</tr>
<tr>
<td>Tree Nuts (cashew, shea)</td>
<td>Kenya, Malawi, Morocco, Tanzania</td>
</tr>
<tr>
<td>Sesame</td>
<td>Burkina Faso, Uganda, Zambia, Zimbabwe</td>
</tr>
<tr>
<td>Herbs (culinary)</td>
<td>Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Morocco, Mozambique, South Africa, Tunisia, Zambia, Zimbabwe</td>
</tr>
<tr>
<td>Spices (culinary)</td>
<td>Cameroon, Egypt, Ethiopia, Madagascar, Malawi, Mozambique, South Africa, Tunisia, Zambia, Zimbabwe</td>
</tr>
<tr>
<td>Medicinal / Therapeutic Herbs and Spices</td>
<td>Egypt, Morocco, Namibia, Tunisia, Zambia</td>
</tr>
<tr>
<td>Essential Oils</td>
<td>Madagascar, Tanzania</td>
</tr>
<tr>
<td>Honey</td>
<td>Algeria, Malawi, Tanzania, Tunisia, Zambia</td>
</tr>
<tr>
<td>Other Forest Products</td>
<td>Uganda, Zambia, Zimbabwe</td>
</tr>
<tr>
<td>Cereals</td>
<td>Egypt</td>
</tr>
</tbody>
</table>

Source: Archived at http://www.orgprints.org/5161

Badgley *et al.* (2007) state that with the exception of the Maghreb countries and Egypt, which benefit from their proximity to European markets, the potential of an export-led organic strategy is constrained by high transport costs and poor infrastructure. For most sub-Saharan African countries the best potential for organic exports undoubtedly lies in low volume high value
crops (such as coffee, herbs, spices, medicinal and beauty products), non-perishable items and those which offer opportunities for adding value locally, such as tropical fruits (which can be dried or juiced). Domestic markets for organic produce are developing in Egypt and South Africa, both reasonably prosperous countries by African standards. In other African countries and particularly in the larger cities, there are reports of some demand for ‘naturally’ grown produce. Often, however, this is not certified and its popularity is often due to these products tasting better than their intensively grown counterparts. The potential of applying organic approaches within urban farming, which provides a high proportion of fresh vegetables and protein within many African cities, is being explored in some places (GTZ 2007).

**Institutional and Financial Aspects of Promoting African Indigenous Organic Farming**

The importance of adequate institutional frameworks and financial management for adaptation has frequently been pointed out (Burton & Lim 2005). Regarding the institutional framework, organic farming can, in principle, build on the existing general local agricultural institutions. However, a major hindrance is the fact that organic farming using local knowledge and resources is not yet broadly recognized for its potential as a development strategy and even less as a climate change adaptation and mitigation strategy. In particular, its capability to produce yields high enough to replace conventional agriculture to a significant amount is often questioned. In African countries, yields are not necessarily lower, as recent research points out. In organic agriculture, prospects for long-term sustained productivity are given and are different from many intensive conventional farming systems, where, after some decades, decreasing yields are observed (DFID 2004). Specialized institutions for organic farming, such as IFOAM (International Federation of Organic Agriculture Movements) and the Food and Agriculture Organization of the United Nations, have the crucial task of spreading knowledge about organic agriculture. The fastest dissemination of organic farming as a climate change adaptation and mitigation strategy could be reached if it became part of national agricultural policies and the international agricultural policy discourse.

Eyhorn (2007) indicates that organic farming as a climate change adaptation and mitigation strategy does not depend on large financing for the farming system itself. Additional costs come from extension services, the
general provision of information, and, if certified, certification costs. However, it is crucial to have access to international markets and to develop local markets for the products. Borron (2006) states that in the transition phase to organic farming additional financing for the farms may be necessary: training and extension services need to be provided and lower yields for the 2-3 years of the transition period may necessitate some additional support. It is sensible, then, to emphasize knowledge transfer and infrastructure building (including access to markets, etc.), rather than direct monetary transfers only, although such may be necessary in certain cases. The economic viability of organic farming is also likely to increase with increasing energy prices (which makes conventional farming more expensive, due to the energy costs for production of fertilizers and pesticides) and with decreasing levels of subsidies for conventional agriculture. Several options to meet the financial requirements exist in principle. Examples are governmental support and research programs for agriculture, microfinance strategies, biodiversity conservation initiatives (Carroll et al. 2007).

Conclusion
The chapter demonstrated the potential of organic farming as an indigenous African climate change adaptation and mitigation strategy. However, although promising, it is no panacea as several critical issues remain to be resolved through research. Organic farming is often criticized for lower yields in comparison to conventional agriculture but recent research invalidates this prejudice, especially in the context of extensive farming systems, which characterize much of the agricultural production in African countries. Furthermore, the self-adaptive capacity of on-farm breeding to climate change and variability needs to be investigated in detail. In the current situation, access to and increased development of (local) markets for the products, local processing possibilities and export infrastructure are of particular importance for organic farming. This emphasizes the role of international institutions and trade policies. The institutional environment for organic farming as an indigenous and community-based climate change adaptation and mitigation strategy has to be identified and promoted. The knowledge transfer has to be institutionalized. Conversely, it must be realized that this knowledge is tied to specific climatic conditions and cannot be transferred to other areas without due caution and modification.


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Contributors’ information
Anke Weisheit, Mbarara, University of Science and Technology, Uganda
E-Mail: ankeweisheit@web.de

Hassan O. Kaya, Research Office, University of KwaZulu-Natal, Westville Campus, Govan Mbeki Centre, Private Bag X54001, DURBAN 4000, South Africa
E-mail: kaya@ukzn.ac.za
Climate Change and Smallholder Agriculture: The Case of Sustainable Bean Production in Malawi

Ruth Magreta
Department of Agriculture and Applied Economics, Bunda College, University of Malawi

Abstract
There are several factors that limit bean production and productivity in Malawi and among them is the limited availability of seed of recommended bean varieties that can cope with the current physical and economic effects of climate change. This study used the participatory variety selection (PVS) approach in an attempt to put farmers first in identifying farmers’ bean variety preferences in relation to diverse agro-ecological and end-user systems. Through PVS farmers and traders had access to a range of varieties; they use their own criteria to choose varieties based on socio-economic and agronomic characteristics. At each PVS site, farmers chose varieties they preferred depending on traits exhibited in those varieties. Some of the traits liked by farmers included early harvests, dwarfism and pod load, which translate into high yields, resistance/tolerance to pests, diseases and drought resistance, etc. Men and women had their different preferences. Out of the potential 20 varieties tested on-farm and on research stations from 2006-2007 to 2009-2010 cropping season, three bean varieties have been released, namely NUA45, NUA59 and VTTT924/4-4, using data generated from the stations as well as on-farm. Results have indicated that these varieties are high yielding as yields range from 1300kg/ha to 2000kg/ha. Furthermore they are resistant to diseases such as angular leaf spot, rust and anthracnose, plus they are rich in micronutrients like Fe (102ppm) and Zn (35ppm). With climate change, farmers are increasingly keen to obtain varieties that can...
withstand the whims of changing weather: early maturity, drought, heat, diseases and pests, and these varieties through PVS have been identified as an answer to the challenges. These results indicate that with climate change there is the need to make major shifts in varieties grown, cropping calendars and even growing seasons, which may also result in disappearance of some bean varieties that have existed for centuries.

**Keywords:** Climate change, participatory variety selection, bean production, agro-ecology, Malawi

**Introduction**

Since the globe keeps on warming, there is enormous need for crops that will actually survive a hotter, drier environment in order to continue feeding the world’s growing population (Chelsea Green Publishing 2009). Beans are an important crop for food security and nutrition, cash income and agro-ecosystem advancement in Malawi. The Malawi national bean programme along with SABRN and CIAT has developed various bean varieties in the country. These varieties have potential for wider adaptation and use across agro-ecological regions and are also suitable for various market niches. Despite premeditated efforts, the wider uses of these varieties are hampered by limited availability and accessibility of seed of recommended bean varieties that can cope with the current physical and economic effects of climate change. It is important to note that preferences for varieties vary among farmers, traders and consumers. Likewise, varieties vary in their adaptation to diverse environments including biotic and abiotic stress factors. Studies throughout the sub-Saharan Africa region show that the bulk of farmers’ bean seed is supplied through local sources such as farmer saved or traded seed and local seed markets (Sperling et al. 1996; David & Sperling 1999). Unfortunately, these local sources are often detached from the innovations of new bean varieties.

In an endeavour to put farmers first, the use of participatory learning approaches has been a focal point in building capacity of bean farmers to identify challenges and opportunities in assessing seed of new varieties and deal with them using participatory research that draws on new information and indigenous knowledge. Along the same lines, starting in 2007 the International Centre for Tropical Agriculture (CIAT) in Malawi adopted the principles of innovative research and a decentralized seed systems approach,
which foster strategic alliances so as to expose farmers to new bean genotypes, through Participatory Variety Selection (PVS), as well as develop more integrated seed supply systems in partnership with various NGOs, community-based organisations, farmer organisations, government-related organizations and private-sector seed actors. PVS is a mutual and collective learning process that aims to empower rural communities by strengthening their social organization and encouraging them to select promising bean lines based on pre- and post-harvest traits they prefer so that they produce what can adapt to their environment as well as satisfy the market needs and be used for home consumption.

As indicated above, these client-oriented thrusts are being developed in partnership with a broad spectrum of players. Though fragmented to date, these efforts are slowly having results as they are giving both decentralized/farm-based (local) seed producers and large seed producers access to seeds of improved varieties of their choice. CIAT draws from experience from a parallel programme started in Ethiopia in 2004, where there has been notable progress, and the project achieved extraordinary success (Assefa et al. 2005; Rubyogo et al. 2010). The key to success in Ethiopia was the development of a range of partnerships which built on complementary organizational interests. This study uses the PVS approach in an attempt to use existing indigenous knowledge to identify farmers’ bean variety preferences in relation to diverse agro-ecological and end-users systems. The chapter is based on the following specific objectives:

- To enhance skills and knowledge of partners in various aspects, such as PVS and decentralized seed systems; and
- To identify/verify farmers’ bean variety preferences in relation to diverse agro-ecological and end users’ systems (market, food security, gender, traders’ preferences).

The Participatory Variety Selection Approach
This approach focuses on building the skills and knowledge of communities, local service providers and farmers organisations to engage effectively in the selection of promising new crop varieties. This approach encourages clients to make individual decisions by encouraging small-scale farmers to speak out. It is also gender sensitive, where women have an equal opportunity as men to voice their opinions, which is a very difficult thing to do in many
male-dominated African communities. Above all, this approach enables communities to share their indigenous knowledge on what varieties will perform well in the local environments and to help determine whether they will be accepted by both the communities and traders.

**Figure 1: Key steps in participatory variety selection**

1: Farmers stratified by gender category in order to capture perceptions of both gender groups without one group interfering with another’s selection criteria

2: Selection is done based on a scale of 1-5 as worst and best entries. Farmers are given ribbons of different colours for choosing the best and worst entries

3: Resulting in men and women selecting varieties

**Methodology**

To be able to conduct participatory variety trials (PVS) a seed production program was put in place where the identified bean lines/varieties were multiplied using irrigation facilities at Kandiyani irrigation site near Chitedze Agricultural Research Station. A total of 1.5 tons of bean seed of test lines/varieties for participatory variety selection (PVS), including seed of released bean varieties for demonstrations, were produced. These were distributed in
sites located across the country. The increased germplasm was used to implement PVS, at different sites, with different partners, during the three cropping seasons from 2006-2007 to 2008-2009.

When conducting PVS in the field with farmers, farmers are stratified by gender and are given five positive ribbons (coloured) and five negative (black). These are to distinguish between the most preferred varieties and the worst liked varieties. Afterwards they go around the field individually deciding on the traits they will base their evaluations on. Then the votes are counted and farmers discuss why they voted the way they did.

**Results and Discussion**

This study’s emerging results present values of positive preferences for each bean variety over three years of evaluation. The higher the mean positive preference value the more the farmers liked that variety. PVS results showed that there were some varieties (MC 12832-8; VTTT 925/11-7; MR 1358-8; VTTT 924/4-4; and VTTT 924/17-2) that yielded more than the released varieties (UBR 92-25 and Kholophethe). This suggested that there were some potential varieties that farmers could benefit from should they adopt these varieties. However, farmers’ choice of preferred varieties did not necessarily match the ranking based on the yield performance of the varieties. Farmers’ choice of varieties was based on more than yield performance, including early maturity, adaptability to changes in rain patterns and other desirable characteristics. Varieties such as NUA 59 and NUA 45 were among the farmer-selected bean varieties though they were not among the top five high-yielding varieties.

Farmers and traders’ selection criteria included disease resistance, resistance to drought, tolerance to low soil fertility, early maturing, good leaf texture for vegetable, good grain colour, large seed size, high yield and marketability. Based on these criteria, ten bean varieties were selected. NUA 35 was the most frequently selected variety, in five out of six sites, while PAN 150 and MC 12832-8 were selected in two out of six sites. Through PVS, farmers voted for the varieties of their choice. Furthermore, NUA 59 was the most preferred bean variety with a preference value of 8.6, followed by NUA 56 and NUA 45, both with preference values of 6.5 each. VTTT 924/4-4, a sugar bean type, was third with a value of 5.8. Furthermore, it is clear that traders play a great role in influencing the varieties that farmers grow. With climate change farmers are increasingly keen to get varieties that
withstand the vagaries of weather: early maturity, drought, heat, diseases and pests. Hence there is increased demand for new bean varieties as new markets evolve and urbanization increases. Farmers did not like some of the bean varieties due to low-yielding potential, liability to pest and disease attacks, poor adaptation to climate change and other traits.

The criteria for selecting the preferred varieties were established disaggregated by gender across eight PVS sites in Malawi (Figure 2). The results revealed that men and women overwhelmingly agreed on potential marketability and yield potential that depend a lot on disease resistance, drought tolerance and early maturity, among others.

Figure 2: Commonly used criteria for selecting most preferred bean varieties by men and women across the sites where participatory variety selection was conducted

Multi-location Yield Trials for Variety Release of Client-oriented Bean Lines/ Varieties

In order to cross-check farmer preference and researcher-based knowledge, on-station yield trials were set up in research stations across the country. Results indicate that at Chitedze research station several bean varieties were better in yield than the released varieties (Kholophethe and Kabalabala), namely VTTT 924/4-4, NUA 45 and NUA 59, which performed better than Kabalabala. These varieties were also preferred by farmers when they were tested on farmers’ fields. Almost all varieties matured within three months, which most farmers prefer so as to save for food security as well as to bring in a cash income. VTTT 924/4-4 matured late (92 days) while NUA 45 and NUA 59 matured early (71 and 75 days respectively). Mean bean yield
obtained at Nchenachena were significantly different (P<0.05) among varieties with SDDT55-C2 having the highest mean yield (959.7kg/ha). The lowest yield was obtained from NUA 35 (319.4kg/ha). At Nchenachena the yield of bean varieties were low (mean yield of 594.7kg/ha). There were significant differences (P<0.05) between the bean varieties on yield with PAN 150 having the highest mean yield (1725kg/ha) at Bvumbwe. Only two varieties (PAN 150 and MR 13508-6) out-yielded the Kabalabala (UBR(92)25), the check and released variety. Bean varieties at Bvumbwe had intermediate yields compared to yields obtained at Chitedze and Nchenachena. It was observed that those varieties that did very well in one location/site were not the same ones that gave highest yields at the other sites. This might be the differences in attitude, agro-ecology and other agronomic factors.

Through PVS farmers had access to a range of varieties and use their own criteria to choose varieties based on socio-economic and agronomic characteristics. It also created awareness and enhanced farmers’ access to seed of improved varieties of beans of their choice. Finally, out of the potential 20 varieties tested on-farm and on research stations, three varieties have been released, namely NUA 45, NUA 59 and VTTT 924/4-4, using data generated from the stations as well as on-farm.

Results from researchers indicated that the general traits of NUA 45 include: high yielding and good grain (bean) filling with a yield potential of 2000kgs/ha; matures within 65 to 70 days; large grain/seed size (weight of 100 grains is about 50 grams); resistance to diseases and pests such as angular leaf spot, common bacterial blight, web blight, rust and floury leaf spot; rich in micro nutrients such as iron (102ppm) and zinc (35ppm); highly marketable; and good seed colour. Traits of NUA 59 include: high yielding and good grain filling with a yield potential of 2000kg/ha; matures within 65 to 70 days; large grain/seed size; weight of 100 grains is about 50.3 grams; resistance to diseases and pests such as angular leaf spot, web blight and floury leaf spot; rich in micro nutrients such as iron (110ppm) and zinc (45ppm); highly marketable; and good seed colour. Those of VTTT 924/4-4 include high yielding and good grain filling with a yield potential of 2482kg/ha; matures within 75 to 80 days; large grain/seed size; weight of 100 grains is about 40.8 grams; resistance to diseases and pests such as angular leaf spot, common bacterial blight, rust and anthracnose; highly marketable; and has good seed colour.
Conclusion and Recommendations

Use of participatory approaches to select preferred bean varieties rather than prescribing the varieties to clients is especially critical for empowering farmers and creating ownership of the variety development process in rural communities. At each PVS site farmers chose varieties that they preferred depending on traits exhibited in those varieties. The traits liked by farmers included earliness, dwarfism, pod load which translates into high-yields, resistance/tolerance to pests and diseases, drought resistance, etc. Men and women had their preferences. Out of the potential 20 varieties tested on-farm and on research stations from 2006-2007 to 2009-2010 cropping season, three bean varieties have been released, namely NUA 45, NUA 59 and VTTT 924/4-4, using data generated from the stations as well as on-farm. With climate change farmers are increasingly keen to get varieties that withstand the vagaries of weather, mature early, and are drought, heat, disease and pest resistant, and these varieties through PVS have been identified to answer the challenges.

The study clearly shows that integration of indigenous knowledge and scientific knowledge has resulted in the release of varieties that adapt to the current climatic conditions. In terms of policy implications, the results show that sustainability in bean production that adapts well to climate change lies in increased interaction between scientists with farmers and traders. These results indicate that with climate change there is a need to make major shifts in varieties grown, cropping calendars and even growing seasons, which may also result in the disappearance of some bean varieties that existed for centuries.

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**Contributor information**
Ruth Magreta, Department of Agriculture and Applied Economics, Bunda College, University of Malawi, P.O. Box 2109, Lilongwe, Malawi
E-mail: rumagreta@yahoo.co.uk
Tel: +265-999-287-544
Climate Change Effects on Medicinal and Aromatic Plants Used For Primary Health Care in Uganda

Francis Omujal
Henry Ralph Tumusiime
Moses Solomon Agwaya
Grace Kyeyune Nambatya
Natural Chemotherapeutics Research Institute,
Ministry of Health, Kampala, Uganda

Abstract
Traditional medicine is widely used for the management and treatment of various diseases in African countries, especially in rural areas where conventional health care is not easily accessible. The World Health Organization (WHO) has estimated that up to 80% of the population in sub-Saharan Africa relies on traditional medicine to meet their primary health-care needs. With the emergence of diseases associated with climate change such as malaria, diarrhoea and respiratory tract infections, patients have turned to indigenous traditional healing methods using medicinal and aromatic plants (MAPs), vital components of biodiversity. Over-exploitation of MAPs for treatment of climate sensitive diseases and exposure to extreme weather conditions such as drought and floods has led to certain species becoming endangered. In addition, the effect of climate change also causes variability in the bioactive phytochemical components of MAPs. The vulnerability of Uganda to climate change effects has led traditional health practitioners, government and development partners in Uganda to focus on conservation of MAPs and building capacity on adaptation to climate change. Therefore, there is need to conduct further research on the effects of
climate change on the sustainability of MAPs and their variability in bioactive phytochemical components.

**Keywords:** climate change, medicinal and aromatic plants, primary health care

**Introduction**

Traditional medicine is widely used for the management and treatment of various diseases in African countries, especially in rural areas where conventional health care is not easily accessible. The World Health Organization (WHO) has estimated that up to 80% of the population in sub-Saharan Africa relies on traditional medicine to meet their primary health care needs. Traditional medicine has been used for centuries for the treatment of several diseases. In Uganda, this is exemplified in the ratio of traditional healer to patient ratio of 1:3000 compared to the conventional doctor to patient ratio of 1:20000 – a disparity that is considerable.

With the emergence of diseases associated with climate change such as malaria, diarrhoea and respiratory tract infections, patients have turned to indigenous traditional healing methods using medicinal and aromatic plants (MAPs), vital components of biodiversity. Apart from being used raw as medicine, MAPs also constitute new sources of bioactive compounds for drug development in the pharmaceutical industry.

While the relevance of MAPs in primary health care has increased, these plants have been affected by climate change, the greatest environment challenge globally (IPCC 2007). There are increasing reports that the earth’s temperature is increasing due to accumulation of greenhouse gases such as CO$_2$ and hydrocarbons in the atmosphere. This has resulted in extreme weather conditions such as drought and flooding, and caused changes in rainfall patterns, all of which have affected MAPs. According to IPCC, (2007), 20-30% plants are at risk of extinction due to increasing temperatures from 1.5 to 2.5°C, and up to 70% if the temperature increased by 3.5°C. With such an increase in temperature change, the most important MAPs used in health care in African countries will become extinct.

Africa is the continent that is the most vulnerable continent to climate change and the same combination of reasons for this make African MAPs vulnerable to extinction. Uganda is already experiencing this; drought,
Climate Change Effects on Medicinal and Aromatic Plants

Floods and rainfall patterns have changed due to the effects of climate change. Between 1991 and 2007, Uganda experienced El Niño rains, drought, reduction in water levels in Lake Victoria and the retreat of glaciers on mount Rwenzori, which have had a devastating effect on the environment (UNFPA 2009). Uganda’s average temperature is projected to increase by 1.5°C by 2020 and by 4.3°C by 2080. These environmental indicators on climate change in Uganda are a manifestation of negative consequences on MAPs that have become endangered.

Endangered Medicinal Plants in Uganda

There is increasing evidence that MAPs have become endangered due to overexploitation and deteriorating environmental conditions associated with climate change. A project on medicinal plant and biodiversity at Natural Chemotherapeutics Research Institute identified 15 MAPs mostly used by communities to treat several diseases in Uganda (Table 1). The overexploitation of these plants is linked to the outbreak of several diseases due to extreme weather conditions such as drought and floods due to climate change. Floods have led to outbreaks of water borne diseases such as cholera and dysentery and malaria while drought has led to outbreaks of respiratory tract infections such as cough flu and asthma (Ariko et al. 2009).

Currently, malaria, diarrhoea and respiratory tract infections are among the leading causes of illness in Uganda (Ministry of Health 2010). The pressure of disease burden in Uganda due to climate change has caused overexploitation of MAPs in Uganda. The utilization of roots and bark under extreme weather conditions (drought and floods) can affect the survival of MAPs. Therefore, there is need to investigate the effect of climate change on sustainability of MAPs.

Table 1: Endangered medicinal plant species used in treatment of different diseases in Uganda

<table>
<thead>
<tr>
<th>MAPs</th>
<th>Diseases treated by MAPs</th>
<th>Part(s) of plant used</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Capparis erythrocarpus</em></td>
<td>Menstrual pain, anaemia and infertility in women</td>
<td>Stem bark, roots</td>
</tr>
<tr>
<td><em>Carissa edulis</em></td>
<td>Epilepsy, jaundice, backache, worms, threatened abortion, malaria, madness,</td>
<td>Root and stem bark</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Uses</td>
<td>Parts Used</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Dioscorea sansibarensis</td>
<td>Used as contraceptive, abdominal pain, treatment of insomnia and headache</td>
<td>Tubers and leaves</td>
</tr>
<tr>
<td>Dracaena steudneri</td>
<td>Cough, blocked tubes, syphilis, difficult delivery, bareness in women, epilepsy, herpes zoster, worms, headache, high blood pressure and threatened abortion</td>
<td>Stem/root bark, leaves</td>
</tr>
<tr>
<td>Erythrina abyssinica</td>
<td>Cough, ulcers, dysentery, anaemia, epilepsy, generalised body pain, vomiting, syphilis, diarrhoea, gonorrhoea, headache, toothache, poisoning, infertility in women, snake bite, skin diseases, migraine, madness, abdominal pain and demons.</td>
<td>Stem bark, flowers, roots, leaves</td>
</tr>
<tr>
<td>Lonchocarpus laxiflorus</td>
<td>Malaria, fever, snake bites, meningitis, dysmenorrhoea, abdominal pain, backache, pneumonia and infertility in women</td>
<td>Stem bark, roots and leaves</td>
</tr>
<tr>
<td>Maytenus senegalensis</td>
<td>Ulcers, headache, abdominal pain, backache, jaundice, infertility in men and women, worms, cough, asthma, diarrhoea, constipation, spiritual possession, bronchitis and madness</td>
<td>Stem bark, roots, leaves</td>
</tr>
<tr>
<td>Prunus africana</td>
<td>Cancer, abdominal pain, fever, worms, relief of labour pain, dysentery</td>
<td>Roots, stem bark and leaves</td>
</tr>
<tr>
<td>Rauvolfia vomitoria</td>
<td>Epilepsy, high blood pressure, malaria, abdominal pain and fever</td>
<td>Roots, stem bark</td>
</tr>
<tr>
<td>Rhus vulgaris</td>
<td>Abdominal pain, cough, constipation, diarrhoea, snake bites, infertility in women, body swelling, worms and enlarged spleen</td>
<td>Root, leaves</td>
</tr>
<tr>
<td>Securidaca longepedunculata</td>
<td>Madness, generalised body pain, fever, worms (in children), abdominal pain, backache, snake bite, cough, toothache, pneumonia, malaria and bewitchment</td>
<td>Bark, root</td>
</tr>
<tr>
<td>Spathodea campanulata</td>
<td>Jaundice, epilepsy, ulcers, madness, diarrhoea, dizziness, malaria, general body</td>
<td>Leaves, stem bark and roots</td>
</tr>
</tbody>
</table>
Effect of Climate Change in Bioactive Phytochemical in MAPs

Medicinal and aromatic plants produce a diverse array of bioactive phytochemicals which are known to have health-protecting properties and play a vital protective role against several human diseases e.g. malaria, diarrhoea, skin infection, cardiovascular disease, cancer, hypertension, diabetes, asthma and diabetes etc. While much MAP research has focused on screening the bioactive phytochemicals and their efficacy, less has been done on the effects of climate change. Medicinal and aromatic plants interact with the environment to produce bioactive phytochemicals such as alkaloids, terpenoids, carotenoids and phenolic compounds (flavanoid, tannins, courmarins, saponins) (Kubola et al. 2011), which are generally defence mechanisms of plants for protection (Bjorkman et al. 2011). These phytochemicals are synthesized from different pathways in plants. For example, alkaloids are synthesized from amino acids, phenolic compound from phenyl propanoids and acate pathway metabolism and terpenoids from mevalonic acid and methylerythritol pathways (Raisanen 2008).

The interaction between environment and genetic factors in plants affects the production of phytochemical compounds in MAPs production. Climate change effects such as increased CO$_2$ in the atmosphere, rising earth
temperatures and variable rainfall patterns significantly affects the MAPs physiological process (Moretti et al. 2010). According to Gairola et al., (2010), effect of temperature and CO₂ on phytochemical composition of MAPs is dependent on the type of chemical, plant species, age and duration of exposure. Although most plant physiological processes are normal at temperatures ranging from 0-40°C, high temperatures tend to increase production of phytochemicals. For example, high temperatures led to increased volatile compounds in aromatic plants; carotenoids, glucoraphanin and glucoiberin in some vegetables (Bjorkman et al. 2011) and flavanoid in some fruits (Moretti et al. 2010). Elevated levels of CO₂ enhanced phenolic compounds and condensed tannins productions in shrubs and tree species (Hattas et al. 200; Bidart-Bouzat & Imeh-Nathaniel 2008).

The effect of climate change factors on phytochemical production in plants is known and the mechanism by which changes in phytochemical compound production in MAPs take place has been discussed. According to Bidart-Bouzat and Imeh-Nathaniel (2008), an increase in carbon supply due to increased levels of CO₂ in the atmosphere increases allocation of carbon for phytochemical production. At high temperatures, carbon metabolism in plants declines and CO₂ assimilation may become limited, thereby relocating carbon for phytochemical production. The increase in levels of phytochemicals in plant leaves and stem bark is therefore due to translocation of carbon into carbon-based phytochemicals (Zobayed & Kozai 2005). Perhaps with climate change, more phytochemicals will be found in leaves rather than roots and this may reduce over-harvesting the roots for traditional medicine purposes. Future research areas in MAPs should aim to address the effect of climate change on variability in bioactive phytochemical production in different parts of MAPs and this might have significant implications on the claimed efficacy. Whereas climate change has affected phytochemical production, many traditional health practitioners have strategies to adapt to effects of climate change.

**Traditional Healers’ Adaptation Strategies to Climate Change**

The vulnerability of Uganda to climate change has led traditional health practitioners to adapt to climate change effects. Many traditional healers in Uganda have now focused on propagation of MAPs in medicinal gardens, sensitizing communities on conservation of medicinal plants, introducing
new exotic varieties, improving ownership of plants, changing land-use patterns, identifying new sources of MAPs and conducting research on new innovative herbal formulae.

There are already initiatives in Uganda by stakeholders of traditional medicine to adapt to the effects of climate change. For example, there are several medicinal gardens established by government and traditional health practitioners in different districts of the country. Although at Natural Chemotherapeutics Research Institute (NCRI), Ministry of Health, Uganda medical gardens was established for conservation, they are also useful in monitoring the effect of climate change on the species grown there. In addition, community centres for traditional medicine were established at regional levels in Uganda with support from International Development Research Centre (IDRC), Ottawa Canada for conservation and monitoring of the effects of climate change on MAPs at regional level. There are also initiatives by districts, local government and cultural kingdoms such as Buganda and Toro to set up medicinal gardens and this will help to conserve and monitor effects of climate change. Apart from medicinal gardens, backyard medicinal plant cultivation is also being promoted throughout many districts in Uganda to conserve MAPs for primary health care. Seedlings of endangered medicinal plants such as *Prunus africana* and *Warbugia ugandensis* have been distributed to several traditional health practitioners and other interested community members to ensure their sustainability. Besides indigenous MAPs, newly introduced exotic medicinal plants such as *Moringa oleifera* from India and *Artemesia anua* from China that easily adapt to climate change effects have been introduced to Uganda.

Although conservation the strategy through the establishing of medicinal gardens and the introduction of new exotic varieties are working, stakeholders are also being sensitized of the impact of climate change MAPs, through workshops, seminars and the media. The government of Uganda has a policy framework that supports protection of natural resources including MAPs. In addition to government initiatives to address the effects of climate change, development partners such as the Lake Victoria Basin Commission are also training and building capacity in areas of climate change.

**Conclusion and Recommendations**

Although MAPs are very important in the provision of primary health care in the community, the effects of climate change have created a increasing
burden of disease that has resulted in their overexploitation in Uganda. Further, MAPs are becoming extinct because of extreme weather conditions such as droughts and floods. The bioactive phytochemical compounds of MAPs are affected by elevated levels of CO$_2$ and high temperatures. There is need to conduct research on the effects of climate change on the existence of MAPs and the variability in bioactive phytochemical production under different conditions.

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**Contributors’ Information**

Francis Omujal, Henry Ralph Tumusiime, Moses Solomon Agwaya and Grace Kyeyune Nambatya, National Chemotherapeutics Research Institute, Ministry of Health, PO Box 4864, Kampala, UGANDA
Effects of Changing Ambient Temperature on the Oxygen Consumption and the Body Temperatures of Adult Angora Goats

Mpho Setlalekgomo
Botswana College of Agriculture, Botswana

Abstract
Farmers of Angora goats in the Karoo area experience large stock losses during cold and wet conditions. Information on the thermoregulatory responses of the goats to cold and wet conditions is scarce. We recorded the oxygen consumption (VO$_2$), body temperature (Tb), skin temperature (Ts) and activity of six adult Angora wethers from the Karoo in the Eastern Cape, South Africa, at varying conditions of ambient temperature (Ta), fleece length and state of wetness. The experiments were conducted at ambient temperatures of 8°C and 20°C. For unshorn goats, wetness resulted in the elevation of VO$_2$ at 8°C, which is indicative of increased metabolic rate. The mean rectal temperatures of the goats were within the normal range (38.5 – 39.7°C) at 8°C and 20°C. Homeothermy was partly achieved by reduction of Ts, which reduced the temperature gradient between the skin and the air. For shorn goats, the reduction of Ts was 3 – 6°C between Ta 8°C and 20°C while rectal temperature was constant. Therefore the goats had to raise their VO$_2$ to maintain their normal Tb. However, the dry shorn goats at 8°C had lower VO$_2$ than at 20°C. It appears as if the goats abandoned endothermy and became torpid. There was no significant difference in activity of goats at different ambient temperatures. Activity of individual goats varied. The skin temperatures of the unshorn goats at 8°C and 20°C were more or less the same as were rectal temperatures. This suggests that the unshorn goats only used increased VO$_2$ to maintain their body temperature while the shorn goats used both VO$_2$ and Ts. It can then be speculated that the shorn goats were
more susceptible to cold conditions than the unshorn goats which had less insulation and therefore enhanced conductance.

**Keywords:** Angora goats, body temperature, skin temperature, conductance, metabolic rate, oxygen consumption, fleece

**Introduction**
Climate change is occurring globally and poses serious threats to agriculture in some areas. Developing countries are found to be the most affected. Some of the countries are experiencing dry spells, droughts and floods. Since global climate change is real and on-going (IPCC 2007). It is of importance for farmers and people at large to understand what impacts are anticipated on livestock. By understanding the thermoregulatory responses of animals to varying environments, it will be possible to predict how they will respond in the face of global climate change. Farmers may be able to predict if their livestock will be at risk, and therefore come up with strategies to keep their animals safe well in time and to apply indigenous knowledge where possible.

Angora goats are susceptible to cold, wet and windy conditions (Anon 1964; Fourie 1984; Hobson 1994; Ferreira 1999; Anon 2001). Newly shorn and young goats are the mostly affected by the above-mentioned conditions (Hobson 1994). The biggest stock losses due to cold, wet and windy conditions usually occur in the Jansenville, Aberdeen, Steytlerville and Graaff-Reinet areas (Anon 1964; Anon 2001). Engelbrecht, Herselman and Louw (2000) associate the losses of Angora goats during cold spells to the reduced adrenal function that causes a decrease in cortisol production. Few studies had been done on the effect of cold, wet and windy conditions on the body temperature and VO$_2$ of Angora goats (Wentzel, Viljoen & Botha 1979; Fourie 1984). Most of the work has been done on fibre production, nutrition and reproduction (for instance, Van Der Westhuysen & Roelofse 1971; Pretorius 1973; Wentzel & Vosloo 1974; Wentzel, Morgenthal, Viljoen & Van Niekerk 1974).

The aim of this study was to investigate the effect of low ambient temperature on the VO$_2$, rectal temperature, body temperature, conductance and activity of shorn and unshorn goats as well as wet and dry goats.
Methods and Materials

Study Animal

The experiments were carried out on six adult Angora wethers bought from a farmer in the Karoo. Wethers were used because they are easily obtainable from farmers since they play no role in reproduction. A further reason was to avoid oestrus and possible pregnancy in females, which could cause some variations in the results obtained from the experiments. The goats were of the same age, six years old, and had almost the same fleece length since they were previously shorn on the same date. They had masses of 44.5 ± 0.88 (mean ± SE) kg at the start of the experiments. The term shorn goats in this work refers to goats with fleece length ranging from 20mm to 60mm while the term unshorn goats applies to goats with fleece length ranging from 160mm to 220mm.

The goats were housed in the Zoology animal unit at Nelson Mandela Metropolitan University (NMMU). This is composed of several sections, each having a small roofed shelter with a concrete floor for protection against rain and strong wind and a larger open grassed enclosure covered with shade cloth. Lucerne, commercial pellets and water were given ad libitum to the goats, except twenty four hours before each experiment where only water was provided and during the course of the experiment where nothing at all was provided.

Experimental Design

A metal wind tunnel of 0.6m x 0.9m x 2.25m was constructed, with a fan at the rear end. The air movement in the tunnel was calibrated using an anemometer. The flow in the tunnel was laminar, with a constant speed of 3ms⁻¹. The tunnel was designed in such a way that a goat placed inside could not turn round. There was enough space between the sides of the goat and the walls of the tunnel as well as behind the goat to allow laminar flow.

Experimental Procedure

For each experiment, one goat at a time had all food, except water, withheld for at least twenty-four hours before the experiment. The goat was weighed before and after each experiment. The experimental goat was then taken into an environmentally controlled room where a pre-calibrated rectal tempera-
ture probe was inserted 15cm beyond its anal verge, and a small portion on its flank shaved for attachment of a pre-calibrated skin temperature probe with the help of an adhesive tape (Anderson 1958). An activity monitor was attached to the forelimb of the goat, and then the goat was put inside the wind tunnel. The rectal temperature and activity were recorded by a Mini-Mitter mini-logger while the skin temperature was measured using an YSI digital thermometer with a skin surface probe. The mask made of nylon stockings and latex was then fitted onto the goat, and connected to a flexible pipe, which was tied to the roof of the tunnel above the head of the goat to take off extra weight from the goat. As the goat breathed, ambient air moved in via one one-way valve, and exhaled air passed through the second one-way valve to the flexible tube. The exhaled air then passed through two condensation traps, a Miniature Vane anemometer for measuring the flow rate, and a sample was pumped into a pre-calibrated Applied Electrochemistry Ametek Oxygen Analyser. The oxygen analyser measured the oxygen consumed by the goat on continuous basis. The readings were logged into a computer connected to the oxygen analyser. The VO$_2$ was used for the estimation of metabolic rate in this study. The wind speed was kept constant at 3 ms$^{-1}$. Humidity level was also constant at 30% for all experiments. The ambient temperatures used were 8°C and 20°C. The experimental exposure period was four hours. For each experiment, the goat was allowed a 30 minutes settling period in the wind tunnel before readings were taken. The readings for all the measured parameters were taken every minute from 9h00 to 13h00.

The experiments were repeated using wet goats, then shorn dry goats followed by shorn wet goats. Wetting was done by dipping the goat in water for at least three minutes so as to ensure saturation of the fleece with water. Wet goats were given 15 minutes for the excess water to drip before being put inside the wind tunnel. At least five goats were used for each condition. Each goat was given an interval of at least five days between experiments. The temperature probes and the oxygen analyser were calibrated fortnightly to reduce errors contributed by equipment. The readings from both the temperature probes and the oxygen analyser were stable throughout the study period. All the experiments were conducted between 09h00 and 13h00 to avoid effects due to diurnal variations. Rectal temperature was measured to represent body temperature instead of taking the average of various internal sites because rectal temperature reaches equilibrium more slowly than temperature in many other internal sites. The rectal probe was always inserted to a
constant depth of 15cm since the rectum has a temperature gradient (Anderson 1970). Skin temperature was also constantly measured at one area since it varies with different parts of the body (Schmidt-Nielsen 1997).

Data Handling
All data logged into the mini-logger was imported into a spreadsheet (Quattro-Pro Version 8). The rectal temperature readings from the logger and the skin temperature readings recorded from the YSI digital thermometer were corrected using a calibration curve derived using a calibrated thermometer. The distance in a cross-sectional plane between the anal verge and the shaved portion on the flank of each goat was measured and taken to represent the radius, r, from the core to periphery. This was used together with the difference between the rectal temperature (Tr) and the skin temperature (Ts) to calculate conductance ((Tr-Ts)/r). The values of the difference in oxygen content between ambient air and exhaled air recorded in the computer were used together with the flow rate readings and the mass of the goat taken before experiment to calculate the specific metabolic rate of the goat.

Data Analysis
The experiments were divided into three sections (i.e. ambient temperature, fleece length and state of wetness). For each section, the means of at least five goats at a given condition were used for statistical analysis.

One-tailed student t-tests were done on hypotheses concerning VO\(_2\), skin temperature, conductance and activity in that it was anticipated that shorn, wet and low-temperature conditions would increase metabolic rates and related parameters. Two-tailed hypotheses were used for rectal temperatures (as representing core temperature) as it was thought these would remain constant within the time frame of the experiments.

For one-tailed tests, the null hypothesis (H\(_0\)) was taken as condition 1 is less than or equal to condition 2 (C1 ≤ C2) and the alternate hypothesis (H\(_A\)) that condition 1 is greater than condition 2 (C1 > C2). For two-tailed hypotheses, the standard null hypothesis of equality was used (C1 = C2). Multiple pair-wise contrasts were used as opposed to analysis of variance (ANOVA) to allow the testing of one-tailed hypotheses. For all statistical tests the level of significance was taken at 95%.
Results and Discussion

Oxygen Consumption

The VO\textsubscript{2} of wet and dry unshorn goats at 8°C was not significantly greater than at 20°C. This is the opposite of what was hypothesized. The goats were expected to have higher VO\textsubscript{2} at 8°C because 8°C lies outside their thermo-neutral zone (20 – 28°C) (Dukes 1955). Fourie (1984) reported a dramatic heat production by wet shorn Angora and Boer goats at a much lower experimental temperature (1.5°C) than the 8°C used in this study. Wentzel et al. (1979) also reported an increase in metabolic rate of Angora goats exposed to 0°C – 5°C. Webster and Blaxter (1966) also reported a rise in metabolic rate in Cheviot and Suffolk sheep exposed to cold conditions (-10 – +5°C). Slee (1972) on his study on the shorn Blackface sheep exposed to an ambient temperature of 8°C also reported a rise in their metabolic rate. The differences in the findings of this study and other studies may be due to the factors such as circadian variations, acclimation temperature prior to experiments and mass, age and sex of the experimental goats.

Rectal Temperature

The rectal temperature of shorn and unshorn, wet and dry goats at 8°C was not significantly different from that at 20°C as was expected. The rectal temperature of all the goats was within the normal range (38.5°C – 39.7°C) of the rectal temperature of goats (Anderson 1970). The rectal temperatures were expected to be the same because goats are endotherms and should be able to maintain their body temperature. From exposing young and pregnant Angora goats to cold conditions, Wentzel et al. (1979) reported a relatively constant rectal temperature (38.9°C) in goats that withstood cold stress (0°C – 5°C) for 48 hours, and a drop to 34°C in those that collapsed. Bianca and Kunz (1978) exposed three breeds of goats to -5°C and they were all just able to maintain their normal body temperature (38.8°C to 39°C). In this study, none of the goats had a rectal temperature that dropped below average. This could be because in this study only mature wethers were used, the experimental period was shorter (4 hours) and that the experimental temperatures used were higher (8°C and 20°C). The results of this study are in accordance with the findings of Bligh, Ingram, Keynes and Robinson (1965) and Jessen and Kuhnen (1996). Bligh et al. (1965) measured the body temperature of the unrestrained Welsh Mountain sheep over a year and found
them to maintain a relatively constant body temperature. Jessen and Kuhnen (1996) did the same with goats and found the same results.

**Skin Temperature**
The skin temperature of all the goats at 20°C was significantly higher than at 8°C except the skin temperature of unshorn wet goats that was at 20°C. This could have been due to the greater insulation of unshorn goats by their fleece. The skin temperature of all the goats at 20°C was expected to be significantly higher than that of goats at 8°C since 8°C lies outside their thermo-neutral zone. The goats had to reduce the thermal gradient between the skin and the surrounding air to reduce energy loss to the environment.

The results show that ambient temperature has an effect on the skin temperature of adult Angora goats, especially shorn ones. This has implications for farmers, showing that shorn goats in the cold are more susceptible to stress than in warm conditions. The results of the skin temperature of shorn goats are in accordance with Webster and Blaxter (1966) who reported a drop in the skin temperature of Cheviot and Suffolk sheep when air temperature was reduced. Bianca and Kunz (1978) also reported a decrease of 3°C – 5°C on skin temperature (on the flank) of goats exposed to an ambient temperature of -5°C. The reduction of skin temperature in this study was found to be 3°C – 6°C.

**Conductance**
The shorn goats at 8°C had a significantly higher conductance than at 20°C. This correlates with the skin temperature results. All the goats were expected to have a higher conductance at an ambient temperature of 8°C and to decrease their skin temperature dramatically to reduce heat loss from the body to the environment. From this study, conductance was highest for shorn wet goats at an ambient temperature of 8°C. This shows that the combined effect of wetness, fleece length and coldness had a dramatic effect on the goats. From the study on the effect of cold, wet and windy conditions on Angora and Boer goats, Fourie (1984) found conductance to increase with decreasing hair length. This agrees with the results of this work.

**Activity**
The activity of all the goats at 8°C was not significantly higher than at 20°C.
However, unshorn wet goats had higher activity at 20°C than at 8°C. The activity of individual goats varied greatly. The goats at 8°C were expected to be more active than at 20°C in order to generate more heat to maintain homeothermy. According to Whittow (1971), the amount of activity tends to increase as temperature decreases and to be suppressed at high temperatures. However, DeVito and Smith (1959) cited in Whittow (1971) reported no significant difference in the activity of monkeys at 0°C and 25°C.

Through accumulated indigenous knowledge from generation to generation, and of course from the information from weather stations, some local farmers can predict when cold wet spells will occur, and so plan to cope with their impacts on their goats. Indigenous knowledge has been directly applied in climate change mitigation by some local Angora goats farmers through supplementing their goats feed with yellow maize in cold conditions, construction of shelters for goats and dipping of shorn goats in an oil-based emulsion to enhance insulation. Indigenous knowledge is passed from older farmers and farm workers to younger farm workers in the process.

**Conclusion**
It appears as if adult Angora wethers can handle an ambient temperature of 8°C quite comfortably. They did not raise their VO\textsubscript{2} and they maintained a constant rectal temperature. Homeothermy was partly achieved by reduction of skin temperature, which reduced the temperature gradient between the skin and the surrounding air, thus reducing energy loss. There was no clarity on how activity contributed to the regulation of body temperature in this study.

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Contributor information
Mpho Setlalekgomo, Botswana College of Agriculture, PO Box 0027, Gaborone, BOTSWANA, +267-3650121
THEME 3
African Indigenous Knowledge Systems (AIKS) in Climate Change and Natural Resources Management
Involving Forest-Dependent Communities in Climate Change Mitigation: Challenges and Opportunities for Successful Implementation of Redd+ In Tanzania

Thabit Jacob
Institute of Natural Resource Management, University of Dar es Salaam, Tanzania

Abstract
Forests play important roles in climate change mitigation as sources and sinks of carbon dioxide gas. The Norwegian and Tanzanian governments have recently agreed to cooperate with other non-governmental organizations and academic institutions to execute reduced emission through degradation and deforestation activities under the REDD+ framework in order to reduce carbon emissions and minimize impacts of global warming. It is increasingly realized that to ensure successful implementation of REDD+ including all desired side effects it is crucial that the communities which depend on the forests are participating fully and that their rights are respected. Among the challenges faced in the implementation of REDD+ in Tanzania is the issue of participation of the forest-dependent communities. There are concerns that the massive influx of REDD+ funds could result in a sudden increase in the value of woodlands, and that REDD+ funds, while accelerating the process of declaring community forests, could also lead to massive land grabs in which communities would lose out. Both of these scenarios would have very serious implications for forest-dependent communities in Tanzania. Although seminars discussing the REDD+ initiative have been conducted with government representatives and donors, and a draft policy framework for REDD+ in Tanzania has been developed, until recently very little seemed to be clear about the role of forest-dependent communities. This chapter
highlights issues that need particular attention in order to make sure that REDD+ works in the interests of the forest-dependent communities. Full, effective and timely participation of forest-dependent communities in the REDD+ process at all levels can add value to the development of sustainable climate change mitigation and adaptation strategies that are rich in local content, and planned in conjunction with local people. Data collected originated from different relevant secondary materials whereas qualitative data analysis was adopted through critical discussion.

**Keywords:** Climate change, REDD+, Participation, Forest-dependent communities

**Introduction**

Human destruction of tropical forests is estimated to contribute up to 17% of global carbon dioxide emissions, resulting in accelerated global warming (Achard *et al.* 2004; Gullison *et al.* 2007; IPCC 2007; Van der Werf *et al.* 2009). One mechanism proposed to mitigate these emissions is Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, otherwise known as Reducing Emissions from Deforestation and Forest Degradation (REDD). The recently agreed REDD+ is the original concept of REDD, plus sustainable management of forests and the conservation and enhancement of forest carbon stocks. The proposed REDD+ mechanism forms part of an international move to include emissions from habitat change (especially the loss of carbon-rich ecosystems such as forests) in a more comprehensive agreement under the UN Framework Convention on Climate Change (UNFCCC), which it was hoped would become operational in 2012.

At the UNFCCC meeting (CoP 15) in Copenhagen, Denmark, in December 2009, some of the parties developed a draft decision known as the Copenhagen Accord. This accord provides the basis for REDD+ in paragraph 8:

> scaled up, new and additional, predictable and adequate funding as well as improved access shall be provided to developing countries, in accordance with the relevant provisions of the Convention, to enable and support enhanced action on mitigation, including substantial
finance to reduce emissions from deforestation and forest degradation (REDD+) (UNFCCC 2009a).

Tanzania currently benefits from donor funding to help it establish REDD+ actions in the country. These include a NOK100-million (USD80-million) commitment from the government of Norway to support national REDD strategy development, sub-national pilot projects, research and capacity building, investments in measuring, reporting and verification, private-sector engagement, and the establishment and piloting of a Trust Fund (Milledge 2009). It is also receiving USD4.28-million from the United Nations REDD Programme, also largely funded by Norway, which is a collaborative partnership between three UN agencies (the Food and Agriculture Organization, the UN Development Programme (UNDP) and the UN Environment Programme), that operates in nine pilot countries (UN-REDD 2009). Other donor support includes preparatory funding for the development of a Readiness Preparation Proposal from the World Bank’s Forest Carbon Partnership Facility for the development of a national forest-monitoring system (government of Finland, USD5-million) and for improving forest management in the Eastern Arc Mountains from the German Climate Change Initiative (USD3.5-million).

Tanzania focuses on the UN-REDD Programme. This has the overall goal to test whether carefully structured payment mechanisms, and relevant capacity building, can create incentives to ensure actual, lasting, achievable, reliable and measurable emission reductions whilst also maintaining and improving the other ecosystem services that forests usually provide. Proposed interventions under the UN-REDD Programme are coordinated with other REDD+ activities through the national REDD+ Task Force.

Within this global and national framework a multitude of actors at various scales of governance stand to win or potentially lose from policies aimed at protecting forests and avoiding emissions. For local forest communities the stakes are particularly high, since policy reform in forest governance is likely to have a direct impact on their livelihoods. In these remote rural areas live some of the most vulnerable people in Tanzania. Farmers that depend on rain-fed agriculture constitute one of the groups most at risk to climate change. For forest-adjacent communities the forests fills an important function of maintaining eco-system services and supporting local livelihoods and subsistence needs. During periods of stress it provides a safety net of wild foods and medicine. Thus, there is a clear link between
climate change mitigation and adaptation in the forestry sector. Investments in improved governance of forest reserves and benefit-sharing mechanisms have the potential of reducing vulnerability of forest dependent communities.

This chapter outlines the challenges and opportunities of involving forest dependent communities in implementing REDD+ in Tanzania. Already existing summary data are presented on the forests of Tanzania, focusing on the issues of greatest relevance to the facilitation of REDD+: amounts of forest remaining, rates of forest loss from deforestation, and the levels of forest degradation. Although this study relates to Tanzania it has relevance for other tropical developing nations preparing for REDD+.

The State of Play in the REDD+- Negotiations under the UNFCCC

REDD-plus is being developed first and foremost as a climate change mitigation option, but it is also expected to generate considerable biodiversity benefits and ecosystem services, and has the potential to generate benefits for indigenous and local communities. Achieving and optimizing these so called ‘co-benefits’ (or additional or multiple benefits) will require close coordination between actors at local, national and international levels.

The issue of reducing emissions from deforestation was first introduced into the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) by Papua New Guinea and Costa Rica at the eleventh session of the Conference of the Parties (COP) to the UNFCCC in Montreal at UNFCCC COP 13, held in December 2007 in Bali. ‘Reducing emissions from deforestation and forest degradation; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries’ became part of the ‘Bali Action Plan’. In 2008 and 2009, policy approaches and positive incentives relating to this issue were considered in the negotiations under the Bali Action Plan.

At its sixteenth session in Cancun, the UNFCCC COP adopted Decision 1/CP.16, which made a series of recommendations including encouraging developing country parties to contribute to greenhouse gas mitigation actions in the forest sector by undertaking REDD+- activities. Under this decision the implementation of REDD+- will take place in three different phases, starting with:
(i) ‘the development of national strategies or action plans, policies and measures, and capacity building’ followed by
(ii) ‘the implementation of national policies and measures and national strategies or action plans that could involve further capacity building, technology development and transfer and results-based demonstration activities’ and evolving into
(iii) ‘results-based actions that should be fully measured, reported and verified’.

Tanzanian Forest Data in Relation to the Needs of REDD+

The outline of the REDD+ process requires participating developing countries to calculate their area of forest and rates of deforestation and degradation, and hence reference baseline emission levels. The number of guidance documents for calculating emissions is rapidly increasing (e.g. Penman et al. 2003a,b; IPCC 2006; GOFC-GOLD 2009; UNFCCC 2009b, c). There is common agreement that a country participating in the REDD+ mechanism will be recompensed based on positive changes to its forest carbon stocks but no decision has been taken under UNFCCC on whether the financial mechanism involved will be market- and/or fund-based. Tanzania favours a fund-based system (Otsyina et al. 2008; URT 2009). Available national information, summarized below, indicates what still needs to be done in Tanzania and illustrates the scale of the challenge facing tropical developing countries preparing to implement REDD+.

Forest Area

Tanzania has 35-million ha of evergreen forests and deciduous woodlands, extending across 38% of the terrestrial mainland (MNRT 1998; 2001; FAO 2006; Zahabu et al. 2009). Forest in Tanzania is defined in the Tanzanian Forest Act (URT 2002) as an

area of land with at least 10% tree crown cover, naturally grown or planted, and/ or 50% or more shrub and tree regeneration cover; and includes all forest reserves of whatever kind declared or gazetted under this Act and all plantations.
The total forest area can be divided into a number of different ecological forest types according to the WWF ecoregions classification. The different forest types contain carbon in different densities (FBD 2007) and also vary in their biological significance and value to people’s livelihoods (Burgess & Clarke 2000; Burgess et al. 2007; Campbell et al. 2008; FBD 2008; Kapos et al. 2008).

**Deforestation**

Deforestation in UNFCCC terms involves a permanent change to another land use (Penman et al. 2003a). The forest area in Tanzania is declining as a result of agricultural expansion, uncontrolled wildfires, intense livestock grazing, illegal mining and charcoal making (FBD 2008). The official Tanzanian deforestation rate is contained in the Global Forest Resources Assessment of 2005 (FAO 2006). For this, Tanzania used data interpreted from 1984 satellite imagery (Millington & Townsend 1989) and compared these with 1995 data (Hunting Technical Services 1997) for the determination of land cover changes. The annual deforestation was calculated as 412 279 ha for forest cover and for woodlands as 1 174 538 ha. More detailed and more recent deforestation rates are only known for some forest types, typically over the period 1990-2000 (FBD 2005). As an example, the area of closed canopy forest in the Eastern Arc Mountains declined by 1% over 10 years, whereas coastal forests declined by 7% and the miombo woodland by 13% over the same period (FBD 2005).

**Degradation**

The UNFCCC definition of forest degradation is ‘direct human-induced long-term loss (persisting for X years or more) of at least Y per cent of forest carbon stocks (and forest values) since time (T) and not qualifying as deforestation’ (Penman et al. 2003a). Therefore, even an area that is temporarily devoid of trees may still qualify as degraded forest even if those trees are likely to grow back.

Tanzanian forests are being degraded because of unsustainable pole-cutting, logging and firewood collection, overgrazing and wildfires. Around towns, forests are being heavily affected by charcoal harvesting (Ahrends 2005; Milledge et al. 2007). However, the extent of degradation and its impact on the carbon stored in Tanzanian forests has mainly been presented
in unpublished case studies (FBD 2007; Malimbwi et al. 2007; Van Beukering et al. 2007). Great effort is required to develop a robust understanding of the level of degradation in the woodland and forest resources of Tanzania. Moreover, a better understanding and analysis of the drivers of forest degradation are required as part of developing mitigation interventions at local and national levels to ensure improved land-use change. This kind of understanding is also crucial for subsequent development of management techniques for ecological restoration (Marshall 2008).

Carbon Storage and Loss
The amounts of carbon stored in different forest types in Tanzania are only partly known (FBD 2007); the carbon density of many tree species is not known; and robust forest-specific equations to convert standard tree diameter and height measurements to biomass carbon have only been established for some forest types (Malimbwi & Luoga 1994; Mattia & Malimbwi 1998; Chamshama et al. 2004; Munishi & Shear 2004; Malimbwi et al. 2005). First order, field survey-based carbon density estimates are lacking for several forest ecoregions (see Burgess et al. 2004 for terminology): East Africa montane forests, Albertine rift forests, southern rift forests, mangrove forest, Victoria Basin forest–savannah mosaic, and northern and southern Acacia (Commiphora bushlands and thickets). Because of these gaps in knowledge, global datasets have been used to generate a preliminary map of carbon density across Tanzania.

Tanzania currently only has sufficient data to calculate carbon loss approximately from deforestation for a limited number of its forest types. For the Eastern Arc Mountains the past 20 years of deforestation have resulted in the loss of 34 million tons of carbon, or 1.7 million tons per annum. Much of this comes from the woodlands and forests outside the network of government-, village-, or co-managed reserved areas (FBD 2007; Hall et al. 2009; Scharlemann et al. 2010).

Involvement of Forest-dependent Communities under Participatory Forest Management (PFM) and Prospects and Challenges under REDD+ in Tanzania
The REDD+ initiative is mainly going to complement previous conservation efforts under the participatory forest management (PFM) scheme. It seems
likely that the combination of PFM and REDD+ will be successful. However, the practical implementation is just one part of it, for a national scheme to work there has to be coordination on a much bigger scale. Several key issues have been identified regarding REDD+, and many obstacles still seem to be in the way of the establishment of an effective and functioning REDD+ process in Tanzania.

**Opportunities from Well-established and Implemented REDD+**

REDD+ has potential for contributing to national foreign income with prospects of carbon trading and private-sector involvement. It can also promote rural development and contribute to the efforts of reducing poverty of the majority and at the same time mitigate climate change challenges. REDD+ will also aid in biodiversity conservation and ecosystem stability. Other opportunities include improving governance because forest-dependent communities will be encouraged to discuss issues and make decisions at the local level and economic benefits with prospects for long-term revenues for local people. Furthermore, there will be job creation and potential for complementary activities such as sustainable forest management. Moreover, ecotourism and maintenance of traditional livelihoods/cultural values associated with forests will be beneficiaries (Yanda et al. 2010).

**Major Concerns for Forest-dependent Communities**

Forest-dependent communities are worried that perpetuation of the negative stereotypes that forest-dependent communities destroy the environment and forests in particular will continue and this will impact negatively on their livelihood activities. There is also a growing concern about the possible promulgation of laws, policies, plans and strategies that could continue to negatively affect forest-dependent communities’ rights to land, natural resources, livelihoods and culture.

The government is likely to implement projects that will impact negatively on the indigenous people’s lives. Benefit sharing is likely not to be taken into account and this means the local economy of these communities could be devastated, with loopholes for corruption and elite capture. There is also the threat of eviction of forest-dependent communities from ancestral land.
Challenges Likely to face Tanzania in Executing REDD+ and the Efforts to Involve Forest-dependent Communities

The implementation of REDD+ in Tanzania and efforts to involve forest-dependent communities in the initiative faces a number of challenges as highlighted below. These challenges will need to be overcome if REDD+ and proper involvement of the forest-dependent communities is to succeed. The challenges include the following.

**Strong Linkages between Social and Ecological Systems**
There is heavy dependency on natural resources and forests, in particular for livelihoods and economic development for forest-dependent communities. Further, the attachment of various cultural and traditional values to forestry resources by local communities is a concern. REDD+ might pose new demands on the natural resources base – how to best fit its emerging needs and how to best tackle the core drivers of deforestation and degradation given social-ecological linkages are questions that need to be addressed.

**REDD+ Based Land Use System Changes**
A major challenge is to ensure the nation’s food security with a shift of focus to carbon trade and the current biofuels needs with more land being reserved for forests and biofuels production. Also, there is a need for proper mechanisms for ensuring sustainability of the REDD+ based activities and income.

**Policy Environment**
There are overlapping policies and poor law enforcement; for instance in preventing illegal logging. These include currently conflicting legislation such as the village act, the land act and the forest act.

**Quality of Databases**
Lack of regular, reliable, specific and accurate data for computing baseline emissions; this is likely to affect the establishment of regular and efficient monitoring systems for accurate quantification of carbon stock.
Issues of Governance
There is a lack of a clear and coordinated institutional framework with different institutional conflicts and overlapping mandates. Also, questions are raised of how to ensure equal benefit sharing between small and large stakeholders as well as mechanisms to improve transparency and address corruption.

Response from the Local Level
People, especially forest-dependent communities, have unfavourable experiences with previous international-based initiatives such as Participatory forest management and joint forest management schemes. Further, there are current global economic problems and previous failure of other sectors to benefit from various global market opportunities, e.g. coffee and cotton farming.

Forest-dependent Communities
There is poor formal recognition of peoples’ rights and their knowledge; indigenous knowledge is poorly acknowledged in the world of scientific knowledge. Forest-dependent communities have a rare chance to participate on various initiatives based on their knowledge, practices and experiences.

The Concept of Participation
How to improve the ‘level’ of participation/involvement of local communities and especially forest dependent communities in developing, implementing and monitoring REDD+ activities is an issue. Also, one has to consider how to ensure active participation of both stakeholders and right-holders including villages owning forests. Again the question of how to improve mechanisms for ensuring free and prior informed concern for the local people during REDD+ execution is also a massive challenge.

Conflicting Interests among Various Stakeholders in Developing and Implementing REDD Initiatives
There are conflicting interests among government bodies (ministries and departments) in terms of decision-making power over REDD+ execution.
These conflicting interests also exist between national and local levels in terms of needs and between politicians and forest conservationists including the vocal civil society organizations.

**Critical Issues to be Considered to Ensure that REDD+ in Tanzania Delivers both to Forest-dependent Communities and to Biodiversity Targets**

The likelihood of REDD+ to succeed as an effective tool for both poverty reduction among forest-dependent communities and climate change mitigation will be achieved only if the following issues are taken into account:

- The need to ensure ethical distribution of funds generated either through carbon markets or from the REDD+ fund to the rightful recipients. Funds should be channelled to improve health services, especially towards fighting against HIV and malaria, and poverty generally, which are highly prevalent in rural areas, where most forest-dependent communities live.

- Ensure that commercial rewards to communities are put towards civil services and projects that strengthen infrastructure. Reliable infrastructure will contribute to assist a range of alternative sustainable livelihoods which address income poverty at the grassroots level.

Carbon sequestration funds should be channelled towards better housing and sanitation to reduce infant mortality, child mortality, and maternal mortality, which have been highlighted by the MKUKUTA as major drivers of poverty in Tanzania. For REDD+ to deliver the anticipated poverty-reduction goals among forest-dependent communities in Tanzania, it must also adopt a ‘pro-poor’ approach, where the poorest people are explicitly targeted in benefit-sharing systems for REDD+. This calls for strengthening accountability and transparency systems into funding programmes at all levels and the need to clarify benefit sharing arrangements especially for land types that are co-managed, and where rights to carbon credits are not clearly defined as is the case in some Joint forest management schemes.
Most importantly land tenure and land ownership must be taken into account if REDD+ is to achieve its intended objectives. Implementing REDD+ can create strong negative effects on local people’s rights to land and related resources, especially for poor people. Increased land demand and land prices, land grabbing and exclusion by the more powerful (including government) are dangers and will affect the poor and landless people to a great deal. Customary tenure and traditional use rights must be recognized and respected.

Conclusion
Establishing REDD+ in Tanzania and Africa in general is a demanding task. A fundamental challenge is that REDD+, is a rich-country initiative to be implemented by the poor countries. The rich is the stronger and poor is the weaker party. This raises the question about which role is offered to the poor countries in crafting out the overall regime for REDD+. Who sets the conditions? It also concerns how substantial the carbon credits transfers will be. Finally, while poor countries are the weaker party, some groups (forest-dependent communities) in these countries are especially at risk. Their interests need to be specifically guarded during REDD+ implementation.

Tanzania has made significant efforts to prepare for REDD+ and, despite slow pace to involve forest-dependent communities, shortages of data and limited technical capacity and some governance shortfalls, the country has embarked on pilot projects in 2010. The relevant government agencies are hopeful that REDD+ will be able to assist in solving the problems of deforestation and degradation and in particular that it will build upon an existing national programme of participatory forest management. However, as discussed in this chapter, a number of significant challenges still need to be overcome if the programme is to be successfully implemented and there is a need to reconsider land tenure issues more seriously as well as a need to build capacities of policy makers considering issues of forest-dependent communities. Capacity building and monitoring will be required and to this end the Tanzanian government is working with NGOs and communities to address these issues, supported by donor funding.
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**Contributor Information**
Mr. Jacob Thabit  
Institute of Natural Resource Management  
University of Dar es Salaam  
PO Box 35069  
Dar es Salaam, TANZANIA
Accelerating Community-driven Initiatives toward Climate Change in Tanzania: Land Use Resource and Livestock Feed Conservation

Elisha Felician
Sokoine University of Agriculture (SUA) Forestry and Nature Conservation Department

Abstract
Tanzania like other countries in the world is facing climate change challenges whereby rural communities seem to be more vulnerable. Globally different research attempts to study climate change impacts tend to focus on the livelihoods of people at macro rather than micro level. In addition to the urban communities, Tanzania is composed of pastoralist and agro-pastoral communities who for years have and still do rely on natural resources for the survival of themselves and their animals. Research findings have revealed that climate changes greatly affect rural communities, especially those who depend on livestock and crop activities to support their lives. Different environmental conservation approaches have been undertaken by traditional people with little assistance from researchers and other stakeholders in natural resource conservation.

The present chapter focuses on the community initiative in respect of the impact of climate change on the agro-pastoralist livelihoods in Tanzania. Previous studies and reports have identified inadequate forage and water supply due to poor management practices and available resources, aggravated by climate change. However traditional knowledge on natural resource management and utilization such as land-use systems, ngitili, and farmer’s altitude on water uses are common practices among agro-pastoral
communities as they respond to climate change. Few projects have been reported to support the initiatives which have top-down approaches for newly introduced techniques. However, knowing community-driven initiatives from household level can facilitate a development-intergraded approach towards climate change and accelerate farmers’ ability to be less dependent and become more self-confident in participating in solutions to climate change as this relates to their own challenges.

Considering the current situation of the pressure of availability of essential resources such as food, livestock feed and water, identifying traditional approaches can help establish practical and cost-effectiveness practices to support conservation and enhance techno-blended solutions towards climate change.

**Keywords:** Tanzania, climate change, traditional knowledge, agro-pastoralist, community driven initiatives

**Introduction**
Tanzania as other countries in the world is facing climate change challenges, mostly in rural communities. Currently climate change is posing a threat to livelihoods, productivity and opportunities, which can be felt either directly or indirectly (Ehrhart & Twena 2006), and in some cases it can have a positive impact too. From the positive side, pastoralists could benefit from receiving rainfall in areas which used to receive low rains resulting into more fodder and longer access to green pasture. Less frequent drought may translate into less time being spent by pastoralists to search for feed. However, climate change has been reported to cause more negative consequences than positive ones, e.g. loss of livestock through heat stress, less livestock feed and loss of agricultural land through erosion.

Climate change is real and climate dynamics have been scientifically explained. In the short term, mainly in 10 to 15 years, the climate variability that pastoralists have seen over the last few years will continue (Kirkbride & Grahn 2008). Adaptation is therefore critical and of major concern to all societies in Tanzania, particularly in rural areas where vulnerability is reported to be high due low adaptation technology and poverty (Hassan & Nhemachena 2008). Although farmers seem to have a low capacity to adapt to the challenge, they have survived and coped in various ways over time
(Hassan & Nhemachena 2008), even if climatic change likely increases the expected frequency and intensity of such threats (Agrawal 2008). Ignoring local community initiatives in conservation has resulted in the failure of many externally activities (Kajembe et al. 2000).

Local institutions have been shaping society on how to respond to environmental challenges in the past and create mechanisms that will translate the impact of negative changes in the future. Since climate change affect all societies, it is critically important to better understand the role of local institutions in shaping adaptation and improving the security of the most vulnerable groups (Agrawal et al. 2008). They shape the community’s response to climate hazards; gather and disseminate information; mobilise and allocate resources; develop skills; build capacity; provide leadership; and network with other decision makers and institutions. Local people are more knowledgeable about local conditions and interrelationships as they have place-based experiential knowledge (Shemdoe 2003). However, a more forward looking intervention or approach to climate change, while also examine community initiatives to ensure that they reach intended social groups. This can also prevent duplication and conflicts among beneficiaries.

**Objective**
The main objective of this chapter is to provide a review of potential community initiatives toward climate change with lessons gained from the pastoral communities of the Dodoma and Singida regions. This chapter dwells on traditional knowledge of resource management and coping strategies toward climate change and the potential contribution of traditional knowledge on climate change mitigation. It also highlights processes which can accelerate community initiatives and their relevance to resource conservation. The information obtained can be used as a baseline for prioritizing areas of mitigation toward climate change at national or sub-national level without contradicting community initiatives towards development.

**Face of Pastoralism in Tanzania**
The United Republic of Tanzania consists of two broad regions, Tanzania Mainland and Zanzibar, with a combined population of 34.57 million, based
on the census of 2002. Currently, it is estimated to be 40 million (URT 2008). About 80% of the land area in Tanzania is classified as semi-arid, dominated by grasslands, dense thickets, woodlands and gallery forests (Shem 2010). Approximately 80% of the population are farmers, pastoralists and agro-pastoralists, where pastoralists and agro-pastoralists control 99% of the available livestock population in the country as their means of living (Shem 2010) and make up an important sector for national economic growth.

Pastoralists have been marginalized socially, politically and economically since the colonial era (Sørensen 2006). Pastoral society in Tanzania suffers from the effects of settlement, encroachment on their traditional pastures, lack of infrastructure, unfavourable market mechanisms, and difficulties marketing their products (DANIDA 1995; Shem 2010). Growing human population, rising of shortage of food crops and other land-use priorities such as mining and national parks and conservation has resulted in the loss of grazing areas (Shem et al. 2005). Moreover, climate change is now posing more developmental challenges regarding available resources by shrinking grazing lands and placing the survival of livestock assets at risk, which are making it more difficult for pastoralists to take advantage of the increasing demand for their livestock and its products.

**Traditional Knowledge on Climate Change**

There is an increasing awareness of the necessity to reconcile the contradictions in resource management with modern knowledge systems and indigenous knowledge. Traditional Knowledge (TK) refers to the knowledge, innovations and practices of indigenous peoples with the aim of maintaining indigenous cultures and values (Mclean 2010). Modern knowledge has borrowed some input from traditional knowledge and is still giving some significant and variable support such as botanical medicine. It has become evident that to unlock potential, indigenous knowledge can help modern researchers to address significant challenges in resource management and development of new pathways for sustainable development for local and modern communities. Local institutions that embody stable, valued, recurring patterns of behaviour preserve heritage in a given society. They can responsibly regulate resource utilization and are reported to be powerful in some parts in Tanzania. Although a participatory approach is one of the key guiding principles of the NAPA process, there has been to date little
It has been reported that communities employ traditional, local and indigenous knowledge (TLIK)-based practices to cope with the negative impacts of climate change. TLIK practices can: avoid risks such as loss of livestock; herd accumulation; use of supplementary feed for livestock; reserving pasture for use by young, sick and lactating animals in case of drought; disease control in livestock and grain preservation; use of indigenous techniques in the management of pests and diseases; culling of weak livestock for food; and multi-species composition of herds to survive climate extremes (Agrawal 2008; Odero 2011). It was also found that grazing areas are allowed to be set aside and recover to be used during period of forage shortage.

It has also been reported that pastoralists employ traditional ways of conserving feed resources. Ngitili is one of most widely known technologies of pasture conservation, and is defined by village or inter-village assembly in the Sukuma community in the Mwanza and Shinyanga regions of Tanzania. However, the modern interventions toward environmental challenge have long ignored local institutions (Kajembe 2000). Indigenous peoples have very different circumstances and have experienced different impacts of climate as well as its geographical, social, cultural and economic situations, and traditional knowledge has the potential to assist in addressing the vulnerabilities associated with climate change. Dagashiga is another local institution reported to be powerful in Bariadi district for the combination and articulation of indigenous knowledge, attitudes and practices, and in regulating access to natural resources within communities (Johansson & Mlenge 1993).

Gender is included in TLIK, which defines knowledge of indigenous plant and animal species, especially drought-tolerant and pest-resistant varieties; water harvesting technologies; water conservation techniques to improve water retention in fragile soils; and food preservation techniques such as fermentation, sun drying, use of herbal plants, ash, honey and smoke to ensure food security (Odero 2011). Transhumance is another approach that has been practised among pastoralists by allowing animals to fertilize the land resources.
Community Initiative and Adaptation
Climate change is inevitable and is already being felt by many of the world’s poorest communities. In response, various efforts have been made to define the meaning and develop suitable adaptations. The term climate adaptation can be defined as ‘processes, practices or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate’ (IPCC 2001). Different societies have different adaptive capacities and engage in activities with various perspectives such as income generation, health, education energy etc. that address mitigation to climate change. Therefore, interventions should help people adapt their livelihoods to changing their climatic and ecological conditions (Ehrhart & Twena 2006).

Pastoralist people are those whose way of life largely depends on mobile livestock herding (Kirkbride & Grahn 2008). Pastoralists live in a wide range of environments predominantly in arid and semi-arid lands. Pastoralists of Africa have been evolving in response to climate variability for 6 000 years (Brooks 2006). They have been able to live with little water by enabling their people to adapt to an arid and unpredictable environment through shifting priorities to search for water and pasture while making effective and efficient use of land (Brooks 2006). However, this method seems to be not applicable in some places due to reduced land used for grazing.

Indigenous Climate Forecast Information
The experience of working with rural communities especially pastoralists revealed the existence of traditional methods of forecasting climate to implement seasonal activities. Most of the people acknowledge the existence of indigenous indicators or signs used to warn of an impending climate anomaly drought/ floods (Interim Report 2002). Climate or weather is perceived by many as something that has to do with sky conditions, including cloud cover, rainfall, temperature and wind, and their associated variability. Changes in temperature variability are associated with good or bad years. Generally, most people perceive climate anomalies or variability as phenomena that have to do with frequent or occasional droughts and floods in a particular season.
According to the promotion and integration of indigenous knowledge in seasonal climate forecasts report (2002), the appearance of certain trees is another indicator for forecasting climate changes in a particular area and it can be viewed from the flowering and the development and shedding of leaves before the onset of the rains indicate the type of the season expected. The village elders or chairpersons are mainly the custodians of the forecast knowledge and are responsible for transmitting information and technology informally (Interim Report 2002).

Specific examples of the common forecasting approach done by rural communities in Tanzania include using the *Albizia schimperiana* tree which predicts good rains if water drops are found on the leaves of these trees around September and October. It has also been found that a change in wind direction from west-east to south-north is taken as an indicator of good rains while a change from north-south to east-west is indication of poor rains. However, indigenous climate forecasting techniques are not quantifiable hence it is difficult to integrate the traditional and conversion approaches. Therefore, the task ahead is to figure out how such traditional indicators can be transformed into quantifiable predictors for better use.

**Indigenous Technology in Mitigating Livestock Feeds**

There are different community initiatives that can address climate change and its impact, and some are not yet well established. From the lesson learnt from the baseline study on livestock feed improvement done in the Dodoma and Singida regions, *Ngitili* is one of the least well identified. *Ngitili* is the pastures reserved by the village assembly and left open periodically for grazing. In this approach, a piece of land is set aside for pasture conservation, mainly natural vegetation, trees and shrubs, to regenerate. It is governed under by-laws and norms accompanied by sanction for those who will not adhere to the agreed laws. Further, it has been revealed that there are two kind of *ngitili* based on ownership; there are communal and private *ngitili* and they differ in size, location and management. Based on size, private *ngitili* range from 0.2ha to 20ha, while communal *ngitili* consist of larger areas, ranging from 10ha to 50ha, depending on the availability and condition of the land. It has been reported that individuals do not have enough land to set aside for pasture conservation, but households with a large herd of animals have found to own private *ngitili* which are used for young and sick
animals. Therefore, communal and private *ngitili* is the most common institution among pastoralists since it involves free access to land of the village in question.

*Ngitili* is one of most widespread indigenous technologies for conserving fodder among the Sukuma pastoralists since 1920s (Kajembe et al. 2000). *Ngitili* are traditionally established on degraded croplands and rangelands, mainly for supplying fodder and other social economic services such as building materials and medicine. They also affect soil restoration through fallowing and nutrient cycling, and protect land ownership rights. The sites are demarcated during the rainy season and then by-laws are set which restrict grazing animals until the most critical fodder shortage period is reached. To ensure prolonged availability of forage and control of land utilization in *ngitili*, pastoralists developed various rotational grazing management strategies with *ngitili* and other open grazing land.

Another common type of indigenous technology is known as *Lyabujije* (which means forbidden) involves woodland and grassland management that restricts access to allow regeneration of woods and other vegetation. Its perspective is focused largely on forest resources, and again the community manages it using by-laws which state what needs to be done and when to do it. In Shinyanga alone, a reported 90.6ha of woodland has been regenerated under this technology (Kajembe et al. 2000). The success of the traditional technology can be attributed to the farmers themselves, implying successful land rehabilitation based on valuable indigenous knowledge. This can be supported by the results from Kamwenda’s (1999) studies which show that 95% of the respondents in Shinganga supported the use of *ngitili* during a dry season for fodder and to reclaim degraded lands.

**Prospective of Community Initiative in Climate Change Mitigation**

As climate change and its impacts become more obvious, it is increasingly important to integrate options, knowledge, technology and other concepts for managing the risks and effects faced by households and communities while not contradicting established development strategies. The need for integrating climate risk management in development as adaptive development is a major concern and requires a greater role for local institutions in both planning and implementation of development projects.
Because the state of knowledge is sparse about the most effective ways in which institutions can facilitate local adaptation, no blueprints can be advanced for planning adaptive development. An adaptive perspective on development will require the willingness to experiment, capacity to take the risk of making mistakes and flexibility to make space for social and institutional learning.

Local communities surrounding natural resources are first beneficiaries and know resources better than outsiders. When negative effects rise they feel them first, therefore, they have a great role to play in any conservation approach. Within a society indigenous technology comprises essential tools and techniques for assessment, conservation and utilization. It encompasses knowledge held by all or most individuals in a particular place; special skills are found within certain persons only and some knowledge is held and dominated by certain groups (Kajembe et al., 2000).

**Conclusion**

There are various reasons to accelerate local technology in the current environment of climatic change. In general, indigenous knowledge is simple and easy to understand since it involves local societies at their most fundamental. It has clear mechanisms for application and low cost adjudication. It has important linkages and interconnections with households and individuals of the society, which creates a flow of knowledge regarding decisions about resources among social groups. Therefore, traditional knowledge is central to local adaptations and will continue to be so because communities strive to adopt measures associated with the long-term health of their resources. Local institutions and their linkages play a crucial role in influencing the adaptive capacity of communities and their adaptation choices (Agrawal et al. 2008). Although some traditional approaches need further findings for verification, it is important to begin to incorporate traditional knowledge on adaptation in relation to the livelihoods of pastoralists and local institutions in the context of adaptation to the adverse conditions.
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**Contributor Information**

Elisha Felician, Sokoine University of Agriculture (SUA) Forestry and Nature Conservation Department, PO Box 3000, Morogoro, Tanzania

Tel: +255-23-2603511/4

Fax: +255-23-2604573
The Perceptions and Experiences on Climate Change and its Impacts by the Traditional Communities of the Western Slopes of Uluguru Mountains, Morogoro, Tanzania

Kassim Ramadhani Mussa
Dar es Salaam, Tanzania

Abstract
The study was carried out to gather the perceptions and experiences of the Uluguru mountains communities on climate change and its impacts, and to understand their traditional innovations in detecting climate change and coping with the impacts. It took place in three villages of Luale ward, namely Luale, Masalawe and Londo in Mgeta division, Mvomero district. Participatory research methods were employed in generating the perceptions, information and experiences about climate change, its impacts and community-based adaptation strategies. Climate-related hazards were identified using traditional knowledge, skills and experiences. Historical timelines developed by the local people themselves revealed an increase in the frequency of drought incidences and shifting rainfall seasons, with unprecedented wildland fires devastating the study area. Community-based coping strategies as a response to the observed climate change impacts were also identified. However, the coping strategies practised by the traditional communities are mainly oriented towards survival, not continuous, motivated by crisis, reactive, often degraded the available resource base and are usually prompted by lack of alternatives. Therefore, local communities and traditional people in general need the support of the international community to continue their role as traditional caretakers of marginal and fragile ecosystems, at the same time, build their capacities to adapt to the impacts of
the current and future changes of global and local climates using more proactive approaches integrated into their indigenous knowledge base.

**Keywords:** Climate change perceptions, indigenous knowledge and skills

### 1.0 Introduction
#### 1.1 Background Information
Climate change is today considered one of the major threats for sustainable development in Tanzania and the rest of the world. It influences health, infrastructure, settlements, food security and agriculture, forests and marine ecosystems. In the United Nations Framework Convention for Climate Change (UNFCCC), adopted in 1992, the International community agreed on mitigation and adaptation as the two basic strategies to deal with climate change. These two strategies are complimentary and non-exclusive (IPCC 2001).

For poor, traditional and natural resource-dependent communities, climate change may compound existing vulnerabilities. Settlement on marginal or unstable lands already heightens exposure to climate hazards. Heavy dependence on ecosystem services places their welfare at the mercy of climatic conditions. As the availability and quality of natural resources decline, so does the security of their livelihoods. Watson *et al.* (1997) concluded that limited resources and capacities for responding to stresses such as droughts constrain the ability of poor communities to meet basic needs and move out of poverty.

Climate change is projected on a global scale and is a global phenomenon. However, different areas and different environments are affected very differently. People too will face different aspects of climate change depending on where they live. The world is usually divided into broad environmental categories within which there are some climate change commonalities but there is also much local and regional variation. In most cases however, traditional people are rarely considered in academic, policy and public discourse of climate change, despite the fact that they will be greatly impacted by impending global changes. Their livelihoods depend on natural resources that are directly affected by climate change, and they often inhabit economically and politically marginal areas in diverse, but fragile ecosystems.
Recent studies have indicated that indigenous and other local people are vital and active parts of many climate change studies and the integration of their knowledge and skills in designing and implementing adaptation projects in highly vulnerable countries may help to enhance the resilience of their livelihood systems to climate change impacts and the resilience of the ecosystems within which they are found. Traditional people interpret and react to climate change impacts in exceptionally creative ways, drawing on their locally available indigenous knowledge and skills which are usually combined with new technologies to find solutions, which may help societies at large to cope with the impending climate change impacts. Therefore, climate change should not be understood as a delicate problem, strictly amenable to scientific fixes, it has profound roots from the indigenous communities in Tanzania and elsewhere in the world.

1.2 Problem Description

While climate models are capable of portraying a bigger picture of climate change and provide estimates for the likely consequences of different future scenarios of human development, they are not very good at providing information about changes at the local level. In recent years, there has been an increasing realisation that traditional groups are a valuable source of this information. Most published reports on indigenous observations of climate change and variability have come from Arctic regions where the co-operation between scientists and indigenous people is strongest. However, it is not only in the Arctic regions where traditional people are observing climate changes. In Africa and in Tanzania in particular, traditional people are observing climate change and they have already started devising the local coping strategies though at the policy level, their efforts to fight climate change are not recognized and not documented yet.

Therefore, the detection of climate change using indigenous knowledge is an essential input when designing the national policies, plans and programmes for addressing vulnerability to climate change impacts. It is against this background that this study sought to utilize indigenous knowledge and skills of the Luguru communities in the Western slopes of the Uluguru Mountains to detect and reconstruct climate change, analysing key hazards and their ensuing impacts and how they have been coping with the observed climate change impacts so far.
1.3 Study Objectives

1.3.1 Overall Objective
General objective was to use locally available knowledge, and skills to understand the local perceptions of climate change, its impacts and the local coping strategies.

1.3.2 Specific Objectives
The specific objectives are:
(a) To explore various traditional innovations applied by the mountainous, forest-dependent communities in detecting the onset of seasons as well as detecting climate change and variability.
(b) To reconstruct the past and present changes in rainfall trends using indigenous knowledge, memories and narrative analysis.
(c) To identify and weigh up major hazards which constrain their livelihood strategies and identify key traditional coping strategies.

2.0 Description of Study Methodology

2.1 Where was the Study Conducted?
This study was conducted in Mvomero district, Morogoro region, covering three villages of Luale ward namely Luale, Londo and Masalawe in Mgeta Division. Mgeta division lies in the Western slopes of the Uluguru Mountains, which is part the Eastern arc mountain ranges comprised of Uluguru, Usambara and Udzungwa mountains. The Uluguru mountains lie immediately South of Morogoro town in Tanzania between latitude 7° and 8°S and longitude 37°-38° E, about 190 km from Dar es Salaam, the commercial city of Tanzania. Different socio-economic activities are carried out around the forest, but agriculture is the major one, which is mostly carried out at subsistence level to produce both food and cash crops.

2.2 Climate of the Study Area
In the Eastern slopes of the mountain, the estimated rainfall is 1200 mm/year, while it is well above 2000 mm on the western slope and the area receives two rainfall seasons per year, the long rains which start in March through
May and the short rains which commence in October through December. The mean annual temperature is about 24.3°C, with a maximum of 26.5°C in December and a minimum of 21.1°C in July (Lyamuya et al. 1994). However, Jens et al. (1993) argues that the mean annual temperature can go down to 19.5°C in certain years, with a maximum of 22°C in December and a minimum of 17°C in July. However this is evidence of small scale change in the climate of areas such as the Eastern Arc Mountains which might be due to the effect of human alteration of the habitat on those mountains specifically through deforestation.

2.3 Why the Western Slopes of Uluguru Mountains?
Having a much higher annual rainfall amount than its Eastern counterpart, less research has been directed in this particular area. In addition, the theoretical assurance, that the Western part of the mountains will suffer less than the Eastern part from climate change impacts called for a non-conventional approaches of detecting climate change and variability since the IPCC models and other scientific tools had reassured the scientific community that the study area is one of those parts of Tanzania which will benefit from the changing climate. So, this study wanted to explore a discrepancy between theoretical assumptions fed into global circulation models and the situation on the ground.

2.4 Methods and Tools
This study employed participatory research methods and tools in generating qualitative and quantitative information about climate change, its impacts and community based adaptation strategies. Primary information was acquired using focus group discussions (FGDs), key informant interviews and narrative analysis from farmers, livestock keepers, elderly people and other livelihood groups.

The FGDs and key informant interviews were used in carrying out resource mapping in order to reveal the key livelihood resources which are both important for their livelihoods and are vulnerable to climate change impacts. Further to this, a focus group discussion was used in developing a vulnerability matrix, which explored the vulnerability of major livelihood resources climate change impacts. Two transect walks were carried out, not
only to complement the focus group discussions but also to triangulate most of the information collected during the focus group discussions.

Pair-wise matrix ranking was used to characterize and weigh up key hazards in the study area, ultimately determining the relative position and importance of climate-related hazards to the livelihood systems of these mountainous communities.

A narrative analysis enabled the development of a historical timeline which identified major climatic events and frequency of occurrences, using traditional knowledge and skills. Phenological markers, most used by indigenous people for detecting the onset, the die-away and divergence of rainfall seasons were identified and documented. These were purely based on indigenous knowledge whereby a list of traditional climatic indicators was developed in the first place, and those markers related to rainfall season prediction were identified and the participants were asked to narrate the mechanisms with which the markers are used for weather forecast, particularly the onset, recession and the quality of a particular season in terms of rainfall amount.

3.0 Results and Discussion
This section discusses how local people have been applying their indigenous indicators to foretell the onset of seasons, the quality of seasons and the digression of seasons from the normal year.

3.1 Traditional Innovations for Detecting the Onset of Seasons and Climate Change
The mountainous communities in the study area have outstanding phenological markers that signal the onset, recession and change of seasons. These ranged from the disappearance of some tree species, appearance of certain insects and noises of some amphibians. With climate change, many of these phenological events are occurring earlier or may be decoupled from the season or weather that they used to indicate. Despite the fact that there are so many markers of weather, climate and climate change, only three which pertain to onset, recession and quality of rainfall season are discussed in this chapter.
(a) The Story of the Disappearance of the Fig Mulberry Tree (*Ficus religiosa*) and Climate Change

First and foremost, the disappearance of the Fig mulberry tree (*Ficus religiosa*), (Mkuyu in Swahili as well as the vernacular language of the Luguru) which is a water-loving tree has been used as a signal of lessening rainfall. While in the past the area was endowed with numerous trees of that kind, nowadays, the trees are hardly seen around, and in some places they have been disappearing at an alarming rate, being a precursor of dwindling water resource, both surface and underground. According to an interview with the local people, particularly the elderly, in almost all the places where streams have dried up, the Fig mulberry tree does no longer exist, thus being a good indicator of water scarcity. Whether or not the trees can re-emerge naturally as soon as water becomes plenty needs a thorough research, as this could not solicit reasonable answers from the local people.

(b) Red Ants (*Formica obscuriventris*) and Weather Prediction by Traditional People

Another important indicator for signalling decreasing precipitation are the red ants, *Formica obscuriventris* (Fig. 1). In the first place, the appearance of red ants in a particular year not only indicates imminent rainfall onset as discussed by Chang’a *et al.* (2010), but in the Western slopes of Uluguru Mountains this also signifies a prospect for a good season, with bumper harvests. When flying ants are seen during the rainy season, it is a sign of promising higher rainfall in that year. According to the interviewed people, under the changing climate, red ants have been as sporadic as the rainfall itself. Since their appearance is correlated to a good rain season, conversely, their disappearance reflects decreasing rainfall.

![Figure 1: Red ant (*Formica obscuriventris*)](image_url)
The Sounds of Frogs and the Onset of the Rainfall Season
When frogs start shouting, it indicates near rainfall onset. When the intensity of the noise increases, this tells people that there will be more rainfall in the coming rainy season. To the traditional people, there is a correlation between the intensity of the noises frogs make and the intensity of the expected rainfall. In this regard therefore, to the traditional people, frogs are good bio-indicators of onset of rainfall and the quality of the rainfall season. That being the case, dwindling seasons can as well be traced using frogs as signs.

3.2 Reconstruction of Past and Present Rainfall Patterns Using Indigenous Knowledge and Skills
Models and records of precipitation mainly focus on changing amounts of precipitation with climate change (and are less accurate than temperature models). In contrast, indigenous people also emphasize changes in the regularity, length, intensity, and timing of precipitation as described in section 3.1. Where precipitation used to occur in clearly delimited seasons of rain in the years before 1960, from the mid-1960s to the year 2010, seasons have become less distinct or occur at different times. In other areas, where precipitation used to be regular, now there may be distinct dry periods and more intense rainfall in shorter periods of time.

A historical timeline carried out using a focus group discussion revealed an increasing trend of drought in the study area (Fig. 2) from the early 1960s to the year 2010 whereby, using their locally available knowledge, memorable events and marks, local community members could show that rainfall patterns have been decreasing, with consequent crop losses. Severe droughts were observed in 1968, 1988, 2006, and around 2007-2008. Conversely, 1970, 1980 - 1984 and 1997 - 1998 were rainfall-laden years. The 1997/1998 season in Tanzania is a remarkable one since this is when El Nino came to the attention of many Tanzanians, both the elites and those using the Indigenous Knowledge.

These findings disagree with the findings of the Initial Communication Report to the United Nations Framework Convention on Climate Change (UNFCCC) and The National Adaptation Plan of Action (NAPA) of 2007 which clearly show that areas with bimodal rainfall patterns will experience increased rainfall of 5–45% and those with unimodal rainfall patterns will experience decreased rainfall of 5–15% under changing climate
conditions (URT 2005). The western slopes of the Uluguru Mountains being one of the bimodal regions in Tanzania: it was expected to experience an increase in rainfall by around 5-45% as per the model predictions. The situation on the ground shows a much faster decrease in rainfall. This shows clearly that indigenous knowledge, apart from complementing the scientific knowledge, can altogether be a reliable source of information, this study has found.

![Graph showing historical timeline with Local drought Index](image)

**Figure 2:** Historical timeline showing an increasing drought incident in the western slopes of Uluguru Mountains

**KEY:** Decision Criteria

3: 75% to 100% crop loss (Bad year)
2: 50% to <75% crop loss (Poor harvest)
1: 25% to < 50% crop loss (Average harvest)
0.5: < 25% crop loss (good harvest)
0: Wet year with bumper harvest
3.3 Seasonal Rainfall Variations from Indigenous People’s Perspective

Apart from a historical reconstruction of drought trends, the late onset and an early withdrawal of rainfall was detected using the seasonal calendar. The months of March, April and May (MAM) were usually the long-rain months and October, November and December (OND) being the short-rain period. However, recently rainfall seasons have been observed to set on in late March or early April and withdraw in the early days of May. In addition, the same has been happening to the short-rains, whereby instead of setting on in October, the rains now start in November as shown in Fig. 3.

![Seasonal Rainfall Variation](image)

**Figure 3: Seasonal rainfall variation before and after the 1970s**

**KEY:**

3: Wet month (Above normal)
2: Average precipitation
1: Below normal precipitation
0: Dry month
3.4 Climate Hazards, Impacts and Traditional Coping Strategies

Major hazards walloping these mountainous areas were identified using a key informant interview, followed by a focus group discussion. After identifying key hazards, a pair-wise ranking method was used to score the hazards that highly impact their livelihoods. It was realized that climate-related hazards are leading, indicating therefore that climate change is a major problem of concern. Drought (27%) as shown in Fig. 4 was identified as the most nagging of all hazards, followed by wildland fires (25%). While carrying out the pair-wise ranking of hazards, traditional people could ostensibly link drought and wildland fires, adding that these two hazards are intertwined, naming drought as the causative agent of rampant wildland fires.

Being a climate related hazard, drought has been accompanied by food insecurity since the communities around heavily rely on a rain-fed agriculture. On the other hand, wildland fires have been devastating to the cash and food crops, causing massive food shortages. Human, crop and livestock diseases have to a lesser extent been felt - some related to climate change and some being there since time immemorial.

Figure 4: Major livelihood hazards in the study area
In reaction to drought, wildland fires and their accompanying impacts, the local communities have devised several community-based coping mechanisms. For instance, during acute hunger, men would migrate to other places in search for casual labour, leaving women and children behind. Other commonly practised coping strategies include, but are not limited to hunting of wild rats and turning them into meals while waiting for harvests. Remember, rats are unpopular animals in Tanzania, thus turning them into food is the last choice a community would make. Furthermore, micro-irrigation schemes are picking up to complement crop water requirements as a response to rainfall shortages. In addition to micro-irrigation, terracing is also being scaled up as yet another moisture conservation technique. Though it has been practiced in the past, there has been an increased adoption in recent years when drought became more pronounced because of the realization that terraces conserve moisture. However, most of the coping strategies practised by the traditional communities are mainly oriented towards survival, not continuous. Motivated by crisis, they are reactive not proactive. They often degrade the available resource base and are usually prompted by lack of alternatives.

4.0 Conclusion
There is more reliance of indigenous knowledge for weather forecast and climate-related disaster prediction than on conventional weather forecast methods. Thus, it was realized in the study that local people’s perception on climate change is not far too different from the scientific community’s perception. Their indigenous knowledge gives them as much information on the change of climatic variables as does the Global Circulation Models (GCMs) and other scientific tools. Therefore, indigenous knowledge is equally important in climate change studies in Tanzania – as may be the case in other parts of the world. Any interventions on climate change impacts, adaptation and mitigation should take on board indigenous knowledge on climate change detection and adaptation.

Despite all the efforts by the indigenous people to cope with the observed climate change impacts, it is very likely that the projected climate changes will exceed any previously experienced changes and their traditional coping mechanisms may therefore not in themselves be sufficient to deal with the ensuing climate change impacts of climate change. Therefore, local
communities and traditional people in general need the support of the international community to continue their role as traditional caretakers of their fragile ecosystems, at the same time, building their capacities to adapt to the impacts of the current and future changes of global and local climate change impacts using more proactive approaches integrated into their indigenous knowledge base.

References

Contributor information
Kassim Ramadhani Mussa, P.O. Box 35097, Dar es Salaam, Tanzania.
Farmers’ Perceptions of Climate Change and Local Adaptation Strategies in the Highlands of Ethiopia

Mesfin Kassa Admassie
Population, Health and Environment Ethiopia Consortium, Bole Medahniyalem Church, Addis Ababa, Ethiopia

Abstract
This study was intended to examine farmers’ perception of climate change/variability, household level impacts of climate change, and local adaptation strategies in the highlands of Menz Gera Midir district, North Shoa Zone, Amhara Regional State. For the survey, focus group discussions and interviews with key informants were carried out in six Peasant Associations. In addition, 30-years meteorology data of climate variables was analysed. Ninety-nine per cent of the informants perceived that the amount of rainfall has decreased but that the pattern and distribution varies over the decades. About 99.4% of the farmers indicated that temperature has increased over the past decades and the instrumental analysis confirmed the rise of mean minimum temperature by 0.25°C over three decades (1974-2004); three most important coping strategies were identified which include food consumption reduction, borrowing from relatives and engaging in daily labour.

Keywords: Climate change, rainfall variability, farmers’ perception, adaptation strategies, highland Ethiopia

1. Introduction
The 2007 assessment of the Intergovernmental Panel on Climate Change drew a couple of substantially new conclusions which had a marked effect on
policymakers. One of these was that climate change is ‘unequivocal’ and is largely due to emissions of greenhouse gases resulting from human activity and that the effects of this observed global warming can now be detected on every corner of the earth in the form of damaged ecosystems (Letcher 2009: xiii). As a result of the warming, the change in climate is continuing at an increasing pace; it is already impacting on life on the planet and it is highly likely that humankind is to be blamed. The rippling effect of global warming and the change in climate is a serious development issue at global and local scale, as it could make vulnerable the livelihoods of millions of people. The changing climate and the varying weather patterns are bringing drastic impacts on food production, natural resources, and health in many developing countries and exacerbate the already pressing difficulties in all sectors of development.

Ethiopia is one of these vulnerable countries affected by the adverse effects of climate change and variability since the country’s economy is highly dependent on smallholder rain-fed agriculture, with some owners managing less than a hectare of land. The high dependence of the economy on agriculture means it is very sensitive to climate variability and is exposed to vulnerability. Ethiopia has been experiencing the negative impact of the change not only in the lowlands but also in highland areas. Particularly, the highlands are fragile and under different stresses like population pressure and unwise utilization of resources, among other things. Recurrent drought events in the past have resulted in loss of life and property as well as migration (Forum 2008).

Perceptions of climate change are the reasons and explanations that people provide about the attitude they hold about variability and changes to the climate from their long time experiences and knowledge.

Investigating the existing perceptions of climate variability and climate change and the local adaptation strategies of farmers’ is a most timely and crucial affair in the development process of Ethiopia, like other countries. Securing Ethiopia’s economic and social wellbeing in the face of climate change requires that policymakers and stakeholders work together to integrate climate change adaptation into the country’s development process (Assefa et al. 2008).

Temesgen et al. (2008) described adaptation to climate change as a two-step process: the household attitude toward the change in climate and variability and its response to the perceived change through adaptation
whereas Lerner (2008) discussed adaptation as the process of learning and storing knowledge so that others can use it currently and in the future.

According to the IPCC (2001b), the adaptive capacity of the economy to climate change is determined by economic wealth, technology, information and skills, infrastructure, institutions and equity, among others. These factors determine the effectiveness of the strategy to adaptation effort.

Very little attention has been paid to empirically analysed causes and development challenges posed by the threats of climate change so far (Aklilu & Lebachew 2009). Research on the impacts of climate change in Ethiopia has been focusing more in the lowland parts of the country that is largely inhabited by pastoral communities and thus there has been limited understanding of the situation in the highlands. To understand and examine the local adaptation mechanisms local people employ, we need prior understanding of the perceptions of local people. They tend to prefer the use of one option of adaptation for what they perceive to be a challenge. No adaptation without perception. In such a crucial thematic area, research is deficient and of limited scope in the highland area of the country. The study is designed to fill the wide research gap in highland agro-ecology.

The real impacts of climate change and climate variability are manifested and observed in the remote and marginalized pocket areas while the available research that depicts the reality in the local area is found to be smaller than the magnitude of the impact. At the same time, discussions on climate issues take the lion’s share of the different communication media by governments, climate scientists, experts, journalists, and the likes whereas the indigenous voices, experiences and the best practices of the people at the coalface of the problems at place-based areas is given little attention.

This study was intended to examine farmers’ perception of climate change/variability, the household level impacts of climate change, and local adaptation strategies in the highlands by focusing on rainfall and temperature changes and the relation with the meteorological record over the same period, and assessment of the extent of adaptation strategies of the local community. It explores the short- and long-term adaptation strategies carried out by the community and the local government.

2. Methodology
The study employed a cross-sectional survey method where samples were drawn from a predetermined population. A variety of methodologies were
used in the collection of primary and secondary data. The primary data includes household and key informant interviews, participatory assessments of focus group discussions and field observations. Both qualitative and quantitative data were used in primary data collection to provide historical and current information on climate change and variability from 180 households in six Kebele Administrations (KA). The secondary data includes both published and unpublished materials, records of ministerial offices, government statistical abstracts, reports, crop assessment reports, meteorology data as well as other relevant articles.

The main data sources for the study were formal and informal interviews, and direct observations. Participatory approaches were carried out in the selected villages, with the participants in the discussions being drawn from all the sub-villages and representing various segments of the community (such as sex, age, education level and wealth and rank).

Thirty per cent of the KA in the Woreda is purposively chosen from two agro-ecological zones (Dega and Wurch) to represent the Woreda. Stratified sampling was used to select the sample KAs from the Woreda and a systematic sampling method was employed to determine the sample households from the recent list of revenue-paying households.

**Data Collection Instruments**

Different data gathering instruments were utilized to generate the required information in the study area. Structured and semi-structured questionnaires were the main tools used to gather the data from the field. The questionnaires were pretested in the field and some amendment has been made to the questions prior to data collection. A face-to-face interview has been made to all sampled respondents from the selected KAs. A total of twelve women and men were part of focus group discussions that were carried out (Table 1). The discussions unveiled enormous opportunities to tap the indigenous knowledges, skills and experiences of farmers. Recording, photographing and transect walks were used to generate the relevant data.


<table>
<thead>
<tr>
<th>Sample KAs</th>
<th>Men focus group</th>
<th></th>
<th>Women FG (Female)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>Kewula</td>
<td>10</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Atedas Gedenbo</td>
<td>12</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>
Method of Data Analysis

The primary data were analyzed using the adopted Likert scale with 3 scales of measurement to which a respondent farmer agrees, disagrees or is indifferent to the perception and local adaptation questions and the mean of each scale was calculated and compared for their choices. The highest mean value will have the highest perception in a specific climate parameter (Karavas-Doukas 1996). SPSS Version 15.0 and Microsoft Excel 2007 software were used in the analysis of the quantitative data. The results were presented in percentages and frequencies in pie charts, tables, and bar graphs. The long year (30 years) mean of annual, seasonal and monthly precipitation and temperature (minimum & maximum) were computed, the rate of change of the means were obtained and the results were presented in graphs, percentages, and numbers.

3. Description of the Study Area

The study was carried out in Menz Gera Midir Woreda (District) located in the North Shoa Zone of the Amhara Regional State, 282km north of Addis Ababa. The Woreda is located between 10.190 and 10.560E and 39.390N and 39.830N and covers an area of about 110 548ha. It is one of the 105 Woredas in the region. The Woreda consists of twenty-one KAs. One of which is a Woreda town, Mehal Meda. The elevation in Menz Gera Midir ranges between 1 680 and 4 000 meters above sea level. The topography of the Woreda includes 38% rugged terrain, mountainous areas constitute about 25%, flat landscape constitute 23%, valleys and water bodies consist of 13% and 1%, respectively (Woreda MoARD 2009). The land-use pattern of the area is cultivated land (33%), grass/grazing land (34%), marginal land and residential areas 30%, forest and bushes 2% and water bodies 1% (Woreda MoARD 2009).
The climatic conditions range from humid (Wurch) to sub-humid (Dega) with two main agro-climatic zones; sub-humid (Dega) constitutes 76% and humid (Wurch) 24%. The range of mean annual rainfall is 800mm to 1600mm and temperature is 8-18°C.

**Figure 1: Location of the study area**

The Woreda has an estimated total population of 102,420, of which 49,956 (49%) are men and 52,464 (51%) are women. Of the total population of the Woreda, only 10,516 (8%) live in urban centres. The remaining 111,457 (92%) live in rural areas.

Mixed farming (cultivation of crops and rearing of livestock) is the major source of livelihood and comprises about 93% of the total sources of livelihood. The main seasonal crops are barley, wheat and beans. According to the socio-economic survey, about 70% of the farmers’ income is from crop production and 25% from livestock production. Of the livestock population,
60% of the income is generated from sheep. The cropping pattern is predominately subsistence oriented. Wool spinning, weaving, petty trade and the likes are the most common local trades. In sum, the area is endowed with varieties of natural resources such as water resource (perennial rivers and springs that could be utilized for the development of small and medium scale irrigation schemes), construction materials (wood, sand and stone) and a considerable amount of livestock.

The main crops grown in the area are barley, wheat, beans, peas, lentils, and chickpeas. The crop production trend of the Woreda has shown variation throughout the years. According to the data obtained from Woreda MoARD (2010), the trend is towards crop production. According to NMSA, the long rain season, meher, which covers 90% of the total production, lasts from June to September and the short season, Belg, which covers 10% of the total production, lasts from February to May. The seasonality, intensity and distribution of rainfall have not been dependable; it has become unpredictable and unreliable throughout the Woreda. Heavy rain results in water logging and floods, or rainfall ceases to occur. Crop failure is very common in the area whenever the rain stops at the flowering stage of crops. These factors force the farmers to change the cropping pattern as well as the type of crops grown. Frost is among the major factors responsible for low crop production in the area.

Crop pests like aphids are very common in the area and cause high damage to the crops. Considerable loss of yield also occurs due to disease such as smut and root rot. The problem of availability of disease-resistant varieties of crops and the absence of biological pest control methods make the crops vulnerable to diseases and pest attack (Woreda MoARD 2010).

4. Results and Discussion
4.1 Characteristics of Respondents
The total number of study respondents was 180 people. Out of the overall respondents, 78 were male and 22% were female-headed households. The reason for the low level of female respondents is related to the existence of a lower number of female breadwinners (revenue earners) compared to men. Based on age category, 3% are below the age of 25 years, 28% are people between 26 and 35, 28% are between 36 and 45, 21% are between 46 and 55, and the remaining 20% (36) are people above the age of 56 years.
Table 2: Characteristics of respondents

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Sex</th>
<th>Marital Status</th>
<th>Educational Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>&lt;25</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>26-35</td>
<td>36</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>36-45</td>
<td>37</td>
<td>14</td>
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</tr>
<tr>
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<td>5</td>
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</tr>
<tr>
<td>&gt;56</td>
<td>32</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>1</td>
<td>18</td>
</tr>
</tbody>
</table>

However, the age distribution shows that the majority of respondents fall under the age category of 26-55 (76%). As much as 20% were old-age headed households and lower percentage (3.3%) of younger households constituted the sample data of the study. Out of the surveyed female households, 16% were below or equal to the age of 45, and the over 46 age group had lower percentage (Table 2).

Categorizing based on marital status, 80% are married, 12% are divorced and small percent single (5%) and widowed (3%). More respondents belong to the age group between 26-55. The educational level depicts that 37% have primary education, 30% have no education at all, 17% adult education, 14% secondary education and 3% tertiary education. Respondent in primary and secondary educational level constitute 51%. Five respondents who dwell closer to the Woreda town have tertiary education level from private distance education institution (Table 2).

4.2 The Pattern and Trends of Precipitation and Temperature

The annual mean rainfall of the Woreda is 902.1 (NMSA 2004). Three-and-a-half decade old data from NMSA indicates that there has been a fluctuation of rainfall. In the year 1977 and 1980-1981, the annual rainfall amount was above 1500mm and 1460mm, respectively – the highest of the three decades, and the lowest mean annual rainfall was registered in 1984.
(352mm) during the time of a severe drought. Following this sharp drop in rainfall, the remaining consecutive years had rainfall amounts less than 1 000 mm except 1996 (1 014mm), 1998 (1 050mm), 2001 (1 132mm) and 2006 (1 027mm). The computed long-year rainfall pattern has shown declining trend over the decades. The overall reduction of rainfall over the three decades is calculated to be 14.5mm (Fig 1).

Figure 1: Mean annual rainfall in the Woreda

The belg season (short rainy season in March and April) in 1974-1983 had the highest rainfall amount with a high mean value of 54.1mm as compared to the mean value of the two decades. This indicates three decades ago, belg season had the highest rainfall amount for belg production. In the second decade (1984-1993), the amount of belg rainfall had drastically fallen to 49.8mm and in the third decade of observation (1994-2003) the amount significantly dropped to 36.9mm below the amount of the other decades.
The graph (Fig. 2) depicts that, belg (autumn) rain had a higher mean value in the first decade. The subsequent decades showed a sharp decline. This trend had an effect on agricultural productivity, among other factors. The water requirement of crops and the sufficiency of the rain for production are beyond the objective of this research and should be researched further for a detailed analysis. However, the reduction in mean value indicates the reduction of belg rain, which had a negative effect on seasonal agricultural production. Farmers’ perception and explanation indicate that the shift of cropping patterns had taken place from Belg to Meher as a result of the decline in the amount, total failure and/or erratic nature of the belg rain.

In the first decade of the meher (summer) season, the rainfall amount shows a higher mean value (186mm) and the second decade had shown reduction of a mean value by 27% (i.e.135mm). The third decade had an increase in the mean value by 23% (176mm) as compared to the second decade but reduced by 5% from the first decade.

The decadal mean analysis indicates that there was rainfall variability in the meher season which means that the pattern and distribution was varying in the area. When belg and meher seasons were compared, the belg trend shows a declining trend throughout the decades (Fig. 2) while the
meher (summer) rainfall shows great variability throughout the decades (Fig. 3).

From A1B Precipitation model scenarios, the global and continental change of precipitation will be ±20 per cent of the normal year, 1961-1990 (IPCC 2007). This variability will increase by the same percent for Ethiopia. According to a mid-range emission scenario by IPCC, a modest increase in annual precipitation is expected over the country from year 2030 to 2080. The scenario shows an increase of 1.3% to 6.1% by year 2030, 2.4% to 11.6% by year 2050 and 3.9% to 18.9% by the year 2080.

The instrumental records and trend of decadal temperature indicate that in the first decade (1974-1983), fluctuations were observed with the highest in 1979 (9.1°C) and the lowest in 1983 (4.8°C). Because the data was collected some time ago, the exact reasons for the highest and lowest record of temperature couldn’t be verified by the various respondents. The recorded data of annual mean minimum temperature shows inter-annual and intra-annual fluctuations (Fig. 4). The mean annual minimum temperature of the station is 7.1°C.
Very few old-aged people generally say that there was a rise in temperature at one time and severe frost at another time. The year 1983 was prominently remembered by these people as the severe drought year and they call it ‘the 1984 Famine’. But they associate it with the 1984/1985 drought even though it is two years earlier than the so-called severe drought. They characterize the years as a time of freezing temperatures and dusty dry winds blowing on the ground.

The computed rate of change of the minimum temperature for the Woreda over the three decades is 0.25°C whereas the national average of the rise in temperature is 0.37°C (NMSA 2001) in a decade. In belg and meher seasons, the computed result of the recorded data has shown fluctuations. A 0.23°C and 0.77°C rise in annual mean minimum temperature of belg and meher seasons were observed, respectively, in the observation period (1974-2003). This rise has coincided with the qualitative response of respondents. The mean global surface temperature has increased by about 0.3 to 0.6°C since the late 19th century and by about 0.2 to 0.3°C over the last 40 years. Recent years have been among the warmest since 1860, the period for which instrumental records are available (UNEP 2003; Muna 2006).

Nationally, the projection of temperature change over Ethiopia as
compared to the 1961-1990 normal mean annual temperature will increase by about 0.9-1.1°C by year 2030, 1.7-2.1°C by year 2050; 2.7-3.4°C by 2080 over Ethiopia from the IPCC mid-range (A1B) emission scenario (NMSA 2007). Fifty-three years of climatic data in Ethiopia has shown that temperature has been increasing at 0.37°C per decade (NMSA, 2001).

4.3. Farmers Perceptions of Rainfall and Temperature

Of the total number of respondents, about 84% of them indicated that they have heard about climate change and climate variability through extension agents and radio broadcasts.

More than 83% have responded that they have heard about climate change and climate variability and the rest have not. They used the extension agents and radio as the major source of information on climate-related issues. Seventy-seven percent of respondents received climate-related information through extension agents and 61% of the respondents heard through the medium of radios (Table 3). They explained that such issues were not heard during Emperor and/or Derue times, and hearing it now signifies that it is a curse from God.

Respondents in Dega KAs have higher probability to hear about climate than the respondents in Wurch KAs. Most Wurch KAs are located far from Woreda town; DAs prefer to live and work in Dega than in Wurch area and accessories to use radio is restricted in the Wurch area because of its longer distance to the town. In the FGD, it was identified that dissemination of information, including seasonal meteorological information for farmers, would help to increase the awareness and prepare them to take appropriate actions. Farmers and the younger generation of farming communities are becoming eager to get information on weather forecasts and warnings.

<table>
<thead>
<tr>
<th>Means of communication</th>
<th>Agroecology</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dega</td>
<td>Wurch</td>
<td>139 (77%)</td>
<td>109 (61%)</td>
<td>202</td>
<td>50</td>
</tr>
<tr>
<td>Extension agent</td>
<td>109</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td>91</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relatives, friends</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>202</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Means of information communication
Thirty-one of the respondents were double counted; radio listeners have access to extension agents.

Asked about the causes of climate change, 39% indicated supernatural wrath and believed climate change was a punishment from God; 25% attributed the cause to the clearing of forests and bushlands due to cropland expansion; and 36% indicated both. They explain:

_Because we work on Saint’s days, disrespecting the rule of Our Creator and we disobeyed His Commandment, He turned His face against us and the punishment is seen in the climate variability. Unless He gives us good seasons we cannot have good harvests._

The result of perceived attitude of sample farmers on precipitation indicated that 97% farmers from those who responded indicated that they agreed in the decrease of precipitation as compared to the trend a decade ago. They explained that the pattern and the distribution of both seasons (Belg and Meher) have shown variation and fluctuations. Out of this percentage, 66% of the respondents were from Dega agro-climate areas and the remaining (34%) from Wurch KAs.

The extent of the decrease was explained by 83% of the respondents to be high and by 16 percent as moderate. The result indicates uniformity of opinions among farmers. They perceive that the rain is less predictable and short. They also believed that they had witnessed a change in the timing of the rains.

Male respondents (66%) in Dega (cool, humid, highland) area perceived the decrease of rainfall more than the male respondents (36%) in Wurch (cold, highland) KAs. Dega dwellers feel the variability of the rain more than Wurch dwellers whereas Wurch inhabitants still benefit from the cold humidity for agriculture that gives them a lesser sensitivity to the climate changes.

Similarly, female respondents in the Dega area (70%) perceived the variability of the rainfall more than female respondents (30%) from the Wurch area. This is because Dega areas are bordered with the Dega and Kolla areas and the feeling of these KAs, however, Wurch dwellers benefit from the relative humidity and the dew drops.

In one of the Dega focus group discussions, a participant expressed the erraticness of the rain in a local poem as:
Rain of this year has unstable feet to stand for long. Its cloud appears in the evening and disappears at night.

About 65% male respondents from Dega (cool, humid, highland) and 35% from Wurch (cold, highland) KAs reported that there is unpredictable variation in the patterns and distributions of the rain in both seasons (DCA 2009). About 72% female respondents from Dega and 28% from the Wurch area reported similarly as the males. Generally, 67% respondents from Dega KAs were aware of the variation of rain better than the respondents from Wurch KAs.

The survey has also assessed the future expectation and prediction of farmers about the rain, and 60% reported that there will be low rainfall while 28% said it will be moderate rainfall but the intensity of the rain would remain high and the pattern would vary.

The agricultural seasons were assessed from the household survey, FGD and key informants and the response obtained were compared with each other. In addition to the assessment, for the purpose of assertion, recording was made during the interview of farmers, Woreda MoARD and Woreda Administration offices. From the survey, it was found out that, three decades ago, the area was well known as one of the best belg-producing Woreda and used meher as a minor season to produce agricultural crops. There was sufficient rain, soil moisture, minimal crop diseases, absence of frost and less frequent drought occurrences in the Woreda. This situation has been changed since the Dergue regime for a number of reasons. Absence and/or shortage of belg rain, population pressure, soil erosion, God’s wrath and soil infertility were some of the reasons mentioned by farmers that forced them to shift into the meher season. Meher season has also its own characteristics like excess rain, hail storm, severe erosion, frost and crop diseases. Now the major production season remains meher and not belg. People say they are forced to follow the trends of the rain in their agricultural activities.

Comparison of previous and present production seasons were analysed from sample farmers in the survey. And 155 (86%) and 175 (97%) respondents replied that the current season of belg (autumn) and meher (summer), respectively, has shifted to later than the normal duration, has an uneven distribution and its cessation comes early before the crops reach grain-filling stage, which severely affects crop production.

Their perception to the shift of agricultural cropping season was evaluated using the Likert scale based on the agreement and disagreement
questions and the weighted mean was computed and the results presented. Both seasons shifted to later but belg is the more unpredictable and unreliable than the meher season. As far as the perception of temperature is concerned, the responses indicate that 99.4% (179) observed an increase in temperature as compared to the last decade. The response is in line with the report by Temesgen (2008) and NMSA (2001) that explained most farmers are aware of the fact that temperature is increasing and the trend of the temperature is increasing into the future.

Seventy percent of the respondents reported that the extent of the increase of the temperature is moderate, 20% of them identified the rise of the temperature is high and 10% replied as low. The highland dwellers have sensed that change of temperature is real in their surrounding areas and sensed this more than ever before. The inhabitants from humid (Wurch) sensed the change in temperature as low because they still benefit from cool weather. Their prediction of temperature in the future is studied and the result indicates that 82% of households believed that the temperature will rise higher than what it is now. However, the remaining 14% believe that the temperature in the future will be moderate if trees are planted and soil and water conservation is done intensively.

According to the survey, the local evidence of respondents for the change in temperature is assessed and it was found that 98.9% had changed their clothing styles. They used to wrap themselves with locally made thick clothes to keep themselves warm. But now their style has changed to lighter dresses (personal observation also witnessed); 95.6% responded that they avoided walking to distant places to escape from the scorching sun during the day; 82% of the farmers reported that they have changed their working time to early in the morning and increased water consumption (13%) in the household.

4.4. Farmers’ Perception of the Impacts of Climate Change and Climate Variability

(i) Recurrent Droughts
Historically, the area was known to be one of the best belg producing Woreda. For the reason of rain variability, temperature rise, population pressure, land degradation, etc., the performance of agriculture declined over time. Since the 1984 drought (they refer it as ‘Seba-Sebat Dirik’) the Woreda consistently became dependent on relief food supplied by government and
many NGOs. The discussion with the focus group, and key informant interviews, Woreda MoARD and Woreda Administrations offices testify to the same responses.

In 1990 and 2000-2001 there were serious droughts in the Woreda which caused many people to suffer and livestock to perish. During these years, because belg season totally failed and meher season produced a poor harvest, the local government and other stakeholders were providing people with food aid and medical support. The recorded meteorological data indicates that the area received the lowest belg and meher rain for crop production in those years. Moreover, the area is one of the most food insecure Woreda in the zone, having recurrent droughts every year (Woreda MoARD 2010).

All respondents (100%) indicated that the increase in temperature had a negative effect not only on the availability of water but also on the quality and quantity of water. About 99.4% people reported that climate variability and climate change had a negative effect on agricultural activity, which in turn affected the household economy of farmers. By 2020, the likely reduction of yields by 50% from rain-fed agriculture is expected in some countries (IPCC 2007:10).

(ii) Loss of Biodiversity (Local Wheat and Barley)

During the survey, focus group participants, households, key informants and experts identified that three decades ago, there were indigenous varieties of wheat well known to the area called Temezh, Gundle, Dimeto and Bullo and barley typically known to the Woreda known as Netch Mawugie, Tikur Ferkie, Workiye and Kibutie. At present the varieties are disappearing from existence in the Woreda.

From the recent assessments made by Fischer et al. (2005) and recognized by IPCC (2007), wheat production is likely to disappear from Africa by the 2080s. According to them, these varieties were found in surplus quantity in all kebeles but now they are only obtained in the hands of few people in restricted KAs. The cause of its disappearance was explained as follows:

*The weather and the soil during the time were favourable to these crops; its production and yield was also high. As the wrath of God continued, the climate got warmer and the soil became poorer than*
ever before; its productivity became lower and lower until we only benefit the straw rather than the seed. In the meantime, when drought occurs in the area repeatedly, we consumed the local varieties because of its low productivity.

During the Dergue regime, the local government introduced new varieties of wheat (ET-13, Dashen, and Lakech) to the area. The soil and the weather responded well to the new crops and we preferred the newly introduced crops rather than the local one due to its better performance and production. Now, we are on the verge of missing those crops. Typical characteristics of these crops were, they were not affected by pests and diseases unlike the introduced crops.

Moreover, local government officials confirmed that they already submitted the varieties to the Institute of Biodiversity Center (IBC) before they become totally extinct. All agreed that the rise in temperature, variability of rainfall, land degradation, among others, caused the loss of these local crop varieties. North Shoa zone has been identified as the possible areas where greater genetic erosion of grains is expected because of the recurrent drought. As a result, local varieties are at risk of becoming extinct. IBC maintains a large collection of grain from the area to prevent this from happening.

4.5. Household Responses and Local Adaptation Strategies
Household strategies used to cope with the short-term problems identified in the survey. Respondents identified five major coping strategies for short-term climate-induced problems. These are: adjustment of household food consumption (100%); borrowing of grain and/or money from relatives (97%); seeking food aid (97%); searching for daily labour work (96%’); eat the seeds (95%); and, others (26%.) (Fig. 5).
As the climate variability and the change continue for extended periods, farmers also continue to keep implementing adaptation measures as life goes on. They identified six major coping strategies: reduction of food consumption (100%). They say:

*Stomach is nothing but what you show to feed. Our stomach is friendly. It will digest what we provide when it is available and it will keep quiet when food to eat is not available.*

Borrowing from relatives (100%) is a major adaptation mechanism for both food and health (medicines) purposes. The third option of adaptation (100%) is searching for daily work in the vicinity of Woreda, Kebele Administrations, Wollo, Gishie Rabel and Debre Berhan. The other major mechanism of the sample is undertaking crop and vegetable gardening using micro-irrigation (83.8%) on a small homestead plot of land. The sixth choice of adaptation to the sample farmer is sale of livestock and their by-products (82.7%). Farmers usually keep livestock as a local kind of insurance for extremely bad years. They tend to sell livestock only under serious conditions and not under normal circumstances; borrowing from other sources (71.6%) is another coping strategy (Table 4).
Table 4: Household long-term coping strategies

<table>
<thead>
<tr>
<th>Household long-term coping strategies</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of food consumption</td>
<td>100</td>
</tr>
<tr>
<td>Borrowing from relatives</td>
<td>100</td>
</tr>
<tr>
<td>Search for daily labour</td>
<td>97.7</td>
</tr>
<tr>
<td>Crop &amp; vegetable gardening using micro-irrigation</td>
<td>83.8</td>
</tr>
<tr>
<td>Sale of livestock</td>
<td>82.7</td>
</tr>
<tr>
<td>Borrowing from other sources (local institutions &amp; usurers)</td>
<td>71.6</td>
</tr>
<tr>
<td>Others</td>
<td>66.6</td>
</tr>
</tbody>
</table>

NB: percent exceeds 100% for the reason of multiple choices of farmers

Use of traditional water wells, planting highland fruits (such as apple), and construction of soil and water structures are additional mechanisms used.

5. Conclusions and Implications

The research has uncovered the proven indigenous knowledge of highland farmers on climate parameters and climate change/variability in their locality. The erratic pattern and distribution of rainfall and a temperature rise of 0.25°C in the Woreda have tremendous influence upon the production and productivity of rain-dependent agriculture. The frequently recurring rainfall variability and the temperature rise have caused highland farmers’ adaptive capacity to deteriorate. An unpredictable belg and meher seasons in the Woreda have also made them frustrated with their livelihoods. Thus, the ever-changing climate variables have been resulting in negative impacts on the agricultural farming practices of the rural smallholder farmers.

The loss of biodiversity and indigenous wheat and barley crop seeds have been serious threats in the area. With all these and other major effects of rainfall variability and temperature rise, highland farmers are struggling to adapt to the changes.

The adaptation effort of smallholder highland farmers is beyond their capacity. They cannot handle the harm effectively and their limited adaptive capacity demands the concerted efforts and interventions of other stakeholders. Their local adaptation practices need to be encouraged and further explored to strengthen their adaptive capacity. Based on their local effort, government assistance in formulating sustainable adaptive mechanisms is paramount to smallholder farmers in highlands.
References


**Contributor Information**
Mr. Mesfin Kassa Admassie
Population, Health and Environment Ethiopia Consortium
Bole Medahniyalem Church
P.O.Box 4408 Addis Ababa, Ethiopia
Mesfinkassa1@gmail.com
Assessment of Climate Change Impact on Agriculture and Land Use and its Local Adaptation Responses: The Case of Humbo Woreda Southern Ethiopia

Shemsedin Ahmed
University of Addis Ababa, Ethiopia

Abstract
Climate change impacts are one of the most serious challenges of the 21st century with multiple effects on human support systems particularly agricultural productive capacity and ecosystem functioning. This study was intended to examine changes in the pattern of climatic parameters, mainly rainfall and temperature, of the study area and to assess the resulting impacts on agricultural production and land-use, land cover of the area as well as to examine and document local adaptation strategies. The change and variability in the climatic parameters was examined by analysing rainfall and temperature data for the last three decades. The impact of climate change on agriculture and the local adaptation strategies were studied using a questionnaire survey. The impact of climate change on land use and land cover change was assessed using satellite images from three different time periods. The result of analysis of rainfall patterns in the study area showed a slight increasing trend for total annual rainfall through time. However, there was very high variability of annual, monthly and seasonal rainfall pattern in the study area. Average monthly temperature in the study area also showed slight decreasing trends through time. The results showed that the amount and distribution of annual and monthly rainfall caused a decline in agricultural yield. Also, this variability in the climatic patterns also affects the agro biodiversity of the study area. According to the study, the reduction of agricultural production and food insecurity forced the local farmers to
highly depend on forest resource of the area. This in turn resulted in rapid land use and land cover change in the study area. The study revealed that farmers developed some local adaptation strategies to cope with problems such as on-farm, non-farm and off-farm livelihood diversifications, reducing the number of livestock per household, eating drought foods and utilizing social systems for helping each other during severe hazard conditions.

**Keywords:** Adaptation strategies, agriculture, climate change, *Humbo*, land use, land cover

**Introduction**

Many regional summits have dedicated discussion sessions to climate change based on the recognition that the global climate is subject to increasing change. This has become more evident in recent years with its multifaceted effects on human societies and the environment (IPCC, 2007). The problem is recognized as one of the most serious global challenges of the 21st century, with multiple effects on basic human support systems (Pinstrup & Pandya 1998; Eriksen et al. 2008).

The impact of climate change is expected to be most severe in developing countries and on the ultra-poor, partially as a result of deprived economy. As climate change leads to decreasing yields in developing countries, it will further exacerbate food insecurity (Jaochin 2008). Among the poorest regions, Africa’s biophysical and socio-economic environments are highly vulnerable to the impacts of climate change and weather extremes (Davidson et al. 2003; WHO 2003).

The IPCC (2001) has stated that as a result of climate change the least developed countries, including Ethiopia, will experience a range of adverse impacts. Ethiopia is highly vulnerable to the harmful effects of global warming on agricultural production and food security as well as physical infrastructure and ecosystems due to the combination of already fragile environments, dominance of climate-sensitive sectors in economic activity, and low autonomous adaptive capacity (Calzadill et al. 2009). Of all the regions affected by climate change in Ethiopia, the Ethiopian Rift Valley is most at risk. It is characterized by sub-arid conditions and is very sensitive to climatic changes (Amsalu Aklilu & Alebachew Adem 2009).

*Humbo Woreda* is part of the country’s Rift Valley. Uncertainty of seasonal rainfall, flooding, drought and crop failure, high dependence on
food aid, high unemployment rate, low levels of family income, and unutilized human labour are the common challenges faced by farmers in Humbo. Land cover change in terms of woodland clearance and conversion of one form of land to another at the expense of natural resources for sustaining life are main problems facing Humbo Woreda. Despite this, there is limited research-generated knowledge in the area on impacts of climate change and locally developed adaptation strategies and community responses. Therefore, this study was initiated to examine the pattern of climatic parameters, mainly rainfall and temperature, of Humbo in the last few decades and its impact on agricultural production as well as land use and land cover, and thereby to assess the local coping strategies.

**Methodology**

This study was conducted in Humbo Woreda, which is one of the twelve Woredas of Wolayita Zone, SNNP Regional State, in Ethiopia located 420 kms south of Addis Ababa on the main road to Arbaminch at 6° 38’ 6° 54’ N and 37° 35’ E 38° 04’ and altitude of 12171 meters to 2240 meters above sea level.

Monthly and annual rainfall of the study area for 21 years (1988-2009) was collected from the National Meteorological Service Agency (NMSA) and Humbo Woreda Agriculture and Rural Development Office and analysed for pattern of change or variability. Twenty-two years (1984-2006) monthly minimum and maximum temperature recordings at Mirab Abaya station were collected from NMSA. The collected rainfall and temperature data were analysed by SPSS for its patterns of changing or variability trends.

The variability of the rainfall was calculated by coefficient of variation as follows: \( CV = \text{Standard deviation} \); Where, standard deviation is the dispersion of rainfall from the Mean average of the given year or month and mean is average monthly rainfall of the year or total mean annual rainfall of study years.

Quantitative and qualitative data were employed in a household survey. The total sample size of 70 households was selected by considering the objectives of the study as well as recognizing the time and resources available. Informal surveys (focus group discussion and informal interviews) have provided an in-depth understanding of local perceptions of climate change impact and local adaptation strategies so that the multiple dimensions of risk and response are taken into account.
The criteria considered in stratifying the villages of the Woreda were mainly proneness to risk or vulnerability situations and altitudinal range. Totally seven PAs were selected on the basis of suitability of the study and the above mentioned procedures. More PAs from lowland were selected because 70% of the study area is lowland and only 30% of the Woreda is highlands. The sample farmers were randomly selected from each PA. Random sampling was used to select five key informants in each PA ranging in age from 50 to 70, including some young people who, it was expected, knew the communities and significant environmental changes very well for group discussion. For this, a semi-structured questionnaire survey was used to gather available information. Besides the semi-structured questionnaire survey, discussions with local key informants, government and non-government organization working in the study area were undertaken.

Landsat images were used to verify the existence of land use and land cover change historically from 1973 to 2000. A time series of Landsat images (1973; 1986; and 2000) were used. Image processing software (ERDAS IMAGINE 9.1 and ENVY 4.3) was used to process the images. Provided with GPS, the coordinates of major land use types were collected to find accuracy levels of supervised and unsupervised classification procedures, which were implemented to classify the Landsat images into the established land uses. Besides landsat images, interviews based on questionnaires were prepared for response at both household level and from agriculture offices, and historical background information were collected for additional historical perspectives and to strengthen the image analyses. Finally, to acquire the needed information, systematic satellite image data processing and interpretations were made.

Results and Discussion
The analysis of rainfall data for the studied years showed that the total mean annual rainfall was 1146mm, with 279 standard deviation and no considerable change in total annual rainfall through time except slight increasing trends of total annual rainfall in the Woreda with a coefficient of determination 5% ($R^2=0.05$) (Figure 1). Maximum and minimum total annual rainfall was 1854mm in 1996 and 677mm in 1991 and 1993, respectively. The calculated coefficient of variation of rainfall for years under study was 24%. This was one of the indicators for variability of the total annual rainfall pattern of the study area. The range of total annual rainfall was greater than
the mean annual rainfall. From this it can be concluded that there were drought and flooding years and that both could have large harmful impacts on agricultural production. This is also similar to Ayele Tesema (2008), who described that the lowlands of the Wolaita are characterized by significant rainfall variability.

Figure 1: The trend of total annual rainfall pattern

The coefficient of variation for most of the yearly rainfall was greater than 70% (Figure 2) and showed high variability of yearly rainfall even in small amounts of the total annual rainfall like 1991, 1993, 1999 and 2004 and years with high amounts of total annual rainfall like 1996, 1997 and 2008. So, from this it can be concluded that the area showed yearly rainfall variability regardless of amount of total annual rainfall.
According to group discussions with local farmers and in terms of Table 1, the occurrence of drought previously was in every two years and in recent years especially after 2000 twice for consecutive two years and this agreed with the variability of annual rainfall patterns.

<table>
<thead>
<tr>
<th>No.</th>
<th>Decade drought more frequent</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1991-2000</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>After 2000</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

*Source*: This study (N=70)

Monthly average rainfall for the studied years was 94mm but months such as Jan, Feb, Mar, Nov and Dec have below average rainfall and
high variability with coefficients of variation greater than 50% (Figure 3). The rest months also showed significant variability with high monthly average rainfalls. This high monthly rainfall variability from the average rainfall was the main indicator of unreliability and erratic nature of the seasonal rain in the study area.

Figure 3: Rainfall variability and Coefficient of Variation of each month (1988-2009)

ARDO (2010) reported that in the study area, the Belg rainfall starts in the beginning of February and ends at the end of June in normal condition and contributes 67.5% of annual total crop production of Woreda average crop production. While the Meher rainfall (July to September) contributes the rest 32.5% of the Woreda average annual crop production. Therefore, any sort of change in amount or variability on Belg rainy season patterns affects the livelihood of the farming community in the study area. Considering this, the Belg and Meher rainfall changing pattern was analysed. The minimum of mean annual Belg rainy season received 53mm (2009) and the maximum of the mean annual Belg rainy season received 177mm (1996) as shown in figure 4 below. Apparently, the average rainfall received in the Belg rainy
season was 99mm and shown a slight decreasing trend with 9% coefficient of determination. *Belg* rainy season (February to June rainfall) showed small contribution to total annual rainfall and high variability 110% in February (Figure 4).

![Trend of *Belg* mean annual rainy season (1988-2009)](image)

**Figure 4: The trend of mean annual rainfall of *Belg* rainy season**

The rainfall of *Meher* rainy season in figure 4 showed that there was a slight increasing trend in the study area with coefficient of determination of 2% (Figure 5). The *Meher* rainfall which contributed smaller amount of the average yearly crop production, showed its larger contribution of total annual rainfall than the *Belg* rainy season and this could cause flooding, which could have negative impacts on agricultural production during crop product collection and any other time.
Assessment of Climate Change Impact on Agriculture and Land Use

Figure 5: The trend of mean annual rainfall of Meher rainy season.

The average monthly temperature of the study area was found to be 24.3°C (Figure 6). The analysed result showed, the minimum monthly temperature of the study area was found between 18.4°C (Mar and May) and 16.9°C (Dec) and the mean of it was found to be 17.83°C. It showed a slight decreasing trend with 5% coefficient of determination. On the other hand, maximum monthly temperature patterns of the study area ranges between 32.6°C (Feb & Mar) and 28.4°C (Jul) and its mean was found to be 30.69°C. The maximum monthly temperature showed a medium decreasing trend with 16% coefficient of determination.
The Mean annual monthly temperature showed a slight declining trend with 9% coefficient of determination. This contradicted with IPCC (2001b) mid-range emission scenario showed that compared to the 1961-1990 average, the mean annual temperature across Ethiopia will increase by between 0.9 and 1.1°C.

Variability of monthly minimum temperature was slightly higher than the variability of monthly maximum temperature in the study area for the period of analysis (figure 7).
Figure 7: Coefficient of variation of monthly maximum and minimum temperature.

According to the respondents’ estimation for average amount of maize and haricot bean produced per sq.km (Table 2 and Figure 8) in fifteen years ago, five years ago and last year showed a declining trend in highland and lowland of the study area.
Table 2: Trend of Maize & Haricot bean products in 15, 5 years ago and last year

<table>
<thead>
<tr>
<th>NO.</th>
<th>Crop type</th>
<th>Average Maize Product per sq. km in kg</th>
<th>Average Haricot bean Product per sq km in kg</th>
<th>% change in 15 years time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15 years ago</td>
<td>5 years ago</td>
<td>15 years ago</td>
</tr>
<tr>
<td>1</td>
<td>Kolla</td>
<td>58* $10^4$</td>
<td>46* $10^5$</td>
<td>22* $10^5$</td>
</tr>
<tr>
<td>2</td>
<td>Woyne Dega</td>
<td>512* $10^4$</td>
<td>368* $10^4$</td>
<td>32* $10^4$</td>
</tr>
</tbody>
</table>

Source: This Study

![Change in Maize & Haricot Bean yield through time](image.png)

Source: Field Study

Figure 8: The trend of Maize and Haricot bean yields in three different time scales

As table 3 below showed the reason for declining of the yield of both crop types. Consistent with farmers’ perception, Cheke and Tratalos (2007)
described that if rainfall varies from the norm, both in terms of total precipitation and in timing, food security is affected. This also agreed with Ayele Tesema (2008), irregularity in the arrival of the first rains, inadequacy in the amount received, and failure in the middle of the growing season were more pronounced in the lowlands of the study area.

Table 3: Reasons for yield reduction by the respondents

<table>
<thead>
<tr>
<th>No.</th>
<th>Perceived Reason for crop yield reduction through time</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Decline in soil fertility due to unreliable rainfall</td>
<td>58.5</td>
</tr>
<tr>
<td>2</td>
<td>Absence of rainfall after sowing (drought)</td>
<td>85.4</td>
</tr>
<tr>
<td>3</td>
<td>Crop disease</td>
<td>13.4</td>
</tr>
<tr>
<td>4</td>
<td>Weeds</td>
<td>8.5</td>
</tr>
<tr>
<td>5</td>
<td>Product damage by untimely rainfall during product collection</td>
<td>85</td>
</tr>
</tbody>
</table>

Source: This Study

According to Figure 9 and Table 4, the coefficient of variation of total annual rainfall and total annual product of the Woreda (1993-2008) from ARDO showed negative correlation. This showed that it was the variability of climatic parameters that highly affected the crop production of the study area.

Table 4: Correlation of annual total production and CV of annual rainfall of the study area

<table>
<thead>
<tr>
<th></th>
<th>Yearly total crop product</th>
<th>CV of Annual Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly total crop product</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td>CV of Annual Rainfall</td>
<td></td>
<td>-.510(*)</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>
* Correlation is significant at the 0.05 level (2-tailed).
Source: This study

Source: Field Study

Figure 9: Relationship of annual total yield of major crops of the Woreda and coefficient of variation of each annual rainfall.
To check the relationship of amount of yearly rainfall and annual crop yields in the Woreda’s crop production; the following hypotheses was used:

H0: yield of annual crop production was not depended on total annual rainfall
H1: yield of annual crop production was affected by available total annual rainfall

The result of analysis of the relationship between average annual crop production of the Woreda (1993-2008) from ARDO and yearly rainfall (1993-2009) of the Woreda from NMSA by linear regression shown in Table 5 below.

Table 5: The relationship of total annual crop production and mean annual rainfall

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of Square</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1</td>
<td>639655687</td>
<td>639655687</td>
<td>0.127</td>
</tr>
<tr>
<td>Error</td>
<td>14</td>
<td>5667285004</td>
<td>5027629317</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>6306940694</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: This study*

Total crop production = 23 Rainfall -10996, $R^2 = 0.9\%$

Since F-calculated (0.127) is less than F-tabulated for F (.05, 1 and 15 degree of freedoms) which is (4.54), the null hypothesis was accepted, that is amount of rainfall in a given year, was not highly determined of the amount of crop production in the study area. It is only 0.9\% of the variation in annual crop production due to total annual rainfall change for analysed years. Thus, variation of annual crop yield in Humbo Woreda was not significantly dependent on the amount of total annual rainfall, for the studied years, but it was depended mainly on rainfall variability in the production seasons. That is, studied years could have high or low total annual crops yield regardless of total annual rainfall. In general in the study area, it was not the variability of total annual rainfall that determined the reduction or variation in annual crop yield rather; it was determined by monthly and seasonal variability of rainfall, specifically the variability or shortage of Belg rainfall was highly affecting the annual yield. Besides the variation or shortage of rainfall amount the temperature of Belg months (February, March, April, and May) are high to increase evapo-transpiration and decrease soil moisture during production season in the study area.

During group discussions, as it was indicated by the Early Warning Sector of Agricultural Office of the Woreda, droughts had been occurring
once every two years in the study area. However, the drought cycle from 2000 later occurred twice for consecutive two years. Flooding was also, one of the major climate change hazards in the study area. Repeated flash and seasonal floods from *Bilate River* have caused widespread damage of life and property mainly in the lowland part of the *Woreda* through damage of crop land and livestock. Erosion and runoff due to extreme and unexpected rainfall also has considerable contribution to decrease of soil fertility by soil erosion. This was confirmed by household survey that 58.5% of the respondents described that soil erosion due to untimely rainfall caused decrease in soil productivity so that this reduced yield. As the farmers indicated during discussion usually they prepare land for the next production season before the rain comes. But this loosened soil was washed away by intense unexpected rain and this reduced the soil productive capacity.

Drought has been affecting crop production in two principal ways. In one way, it affected the long-term farmers’ perception of cropping patterns. That was during drought years, farmers choose to cultivate low yielding with low food quality but better drought resistant crop varieties such as ‘*Mita Boye*’ (Cassava), *Halako* (*Moringa olifera*), (*Akuri Ater*) rather than higher yielding but non-drought resistant crop varieties. In another way, drought affected crop production through a direct impact on crop yields. Figure 10 below from documentation of the *Woreda* early warning and hazard protection office which depicted the total damage of maize crop due to shortage of rainfall in 2008/9 in the study area. This increased food insecurity on the local community and resulted in loss of human and animal life of those unable to cope up the challenge.
Assessment of Climate Change Impact on Agriculture and Land Use

Source: Documentation center of the Woreda early warning and hazard protection

Figure 10: Totally failed Maize field due to erratic nature of rainfall in the study area in 2008/9

According to group discussion with key informants and Table 6 in the Kola part of the study area, climate variability and change affected the availability of feed in the study area and this has caused long calving period, weak physical conditions and fewer yields (milk, meat, lower market values).

Table 6: Perceived condition of range land through time by farmers

<table>
<thead>
<tr>
<th>No.</th>
<th>Condition of range land through time</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deteriorated</td>
<td>77.1</td>
</tr>
<tr>
<td>2</td>
<td>Improved</td>
<td>5.7</td>
</tr>
<tr>
<td>3</td>
<td>Remained the same</td>
<td>17.1</td>
</tr>
</tbody>
</table>

Source: Field Study
(N=70)
The frequently occurring drought has resulted in increased livestock deaths and poor conditions (Table 7) which were the main livelihood of the farmers that they depended on it.

Table 7: Perceived reasons of respondents for poor cattle body conditions

<table>
<thead>
<tr>
<th>No</th>
<th>Perceived reason for cattle body condition by the respondents</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shortage of pasture</td>
<td>83</td>
</tr>
<tr>
<td>2</td>
<td>Shortage of water</td>
<td>55.7</td>
</tr>
<tr>
<td>3</td>
<td>Drought</td>
<td>85.7</td>
</tr>
<tr>
<td>4</td>
<td>Disease</td>
<td>31.4</td>
</tr>
</tbody>
</table>

Source: Field Study (N=70)

As farmers indicated during group discussions, currently in the lowland some indigenous crops of the area is no longer being produced in the lowland part of the Woreda and it shifted from this area to other neighboring Woredas with higher altitudes. The change in the pattern of temperature and rainfall are the main causes for the disappearance of the crops due to frequent droughts and crops disease. This indicated that the crops were disappearing from the low land because of unsuitability of highly variable climatic conditions of the low land and suitability of high land climatic pattern (Table 8). This is similar with IPCC (2007) that changes in climate have the potential to affect the geographic location of ecological systems, the mix of species that they contain, their ability to provide the wide range of benefits on which societies rely for their continued existence and also its effects vary by crop.

Table 8: Pattern of change in Agro biodiversity through time

<table>
<thead>
<tr>
<th>No .</th>
<th>Crops used to cultivate in the area before 20 years</th>
<th>Name of disappeared crops</th>
<th>Newly introduced in recent years</th>
<th>Current crops diversity</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>Maize (Zea mays)</strong></th>
<th><strong>Tef</strong> (Eragrostis tef)</th>
<th><strong>White bean</strong></th>
<th><strong>Maize</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maize (Zea mays)</td>
<td>Tef**</td>
<td>White bean©®</td>
<td>Maize</td>
</tr>
<tr>
<td>2</td>
<td>Tef</td>
<td>Sweet Potato*</td>
<td>Akuri ater®</td>
<td>S. bicolar</td>
</tr>
<tr>
<td>3</td>
<td>Sweet Potato</td>
<td>H. vulgare**</td>
<td>G. donua®®</td>
<td>P. vulgaris</td>
</tr>
<tr>
<td>4</td>
<td>Sorghum bicolar</td>
<td>W. donua***</td>
<td>Peanut®</td>
<td>Irish potato</td>
</tr>
<tr>
<td>5</td>
<td>Phoselus vulgaris</td>
<td>Gudare**</td>
<td>Peanut</td>
<td>Peanut</td>
</tr>
<tr>
<td>6</td>
<td>Hordeum vulgare</td>
<td>Boye**</td>
<td>Cotton</td>
<td>Cotton</td>
</tr>
<tr>
<td>7</td>
<td>Wolaita donua</td>
<td>E. ventricosum**</td>
<td>Red pepper</td>
<td>Red pepper</td>
</tr>
<tr>
<td>8</td>
<td>Gudare</td>
<td>Gadisa donua*</td>
<td>Moringa olifera</td>
<td>Moringa olifera</td>
</tr>
<tr>
<td>9</td>
<td>Enset ventricosum</td>
<td></td>
<td>Cassava</td>
<td>Cassava</td>
</tr>
<tr>
<td>10</td>
<td>Irish potato</td>
<td></td>
<td>White bean</td>
<td>White bean</td>
</tr>
<tr>
<td>11</td>
<td>Peanut</td>
<td></td>
<td>G. donua</td>
<td>G. donua</td>
</tr>
<tr>
<td>12</td>
<td>Red pepper</td>
<td></td>
<td>Akuri ater</td>
<td>Akuri ater</td>
</tr>
<tr>
<td>13</td>
<td>Cotton</td>
<td></td>
<td></td>
<td>Cotton</td>
</tr>
<tr>
<td>14</td>
<td>Boye</td>
<td></td>
<td></td>
<td>Boye</td>
</tr>
<tr>
<td>15</td>
<td>Cassava</td>
<td></td>
<td></td>
<td>Cassava</td>
</tr>
<tr>
<td>16</td>
<td>Moringa Olifera</td>
<td></td>
<td></td>
<td>Moringa Olifera</td>
</tr>
</tbody>
</table>

*,**,**,** = crops disappeared 5, 10 & 15 years ago respectively
©®,®® = crops introduced 5 & 10 years ago respectively

Source: Field Study
Climate change has direct and indirect impacts on the prevalence and spread of diseases and pests (IPCC 2007). Climate variability and change pose increasing risks to livestock production in the study area. Local farmers pointed out that, with repeated and extended droughts existing, livestock diseases: *Black leg, Gendi / Trypanosomiasis* were causing increased frequency of illness and livestock deaths. Besides this, according to farmers, due the recurrent droughts traditional medicine locally known as “*Qarchacheya*”, disappeared at least ten years ago.

Changing pattern of the local climate has caused crop damage and failures due to moisture stress, diseases and pest infestations. According to discussion with the community of *Méhal Ella*, due to the late onset and insufficient rains, outbreak of *weevils* happened in recent years which previously did not affect and destroy *sweet potato*. For this reason they now totally stopped the production of *sweet potato* in the area.

About 59% of the households in the area indicated that livestock diseases have intensified in recent years compared to the past and have caused increased loss of livestock. Regarding crop diseases and pests, about 61% of the households in the study area said that the prevalence of crop diseases and pests has increased with time. *Woreda* agricultural experts also shared a similar view regarding the increased intensity of crop and livestock diseases and pests.

LU/LC analysis showed that there is an increasing trend of cultivated land covers in the study periods. Conversely, the forest covers, prove to be declining. In relation to this, most of the bush land covers during the study periods were seen to decline. There is supposed to be various driving forces for the type of land use conversions. Apart from the increasing trend of population, the apparent demand of land for cultivation, charcoal production and fuel wood for household consumption and supply for nearby towns as income generation are major factors contributing much to the conversion of land use types in the study area.

According to the key informants in Abela Faricho Village, the area was densely covered with Acacia wood land some twenty years ago. But now, drought which was one of the climatic parameters indirectly became the cause of forest cover change. This forced people to over exploit acacia wood land for charcoaling, fuel wood and construction, to sell it in nearby towns for income generating mechanisms. The farmers utilize the forest resource as coping mechanism because of the agricultural yield loss or decline due to climatic variability (Table 9). This concurs with WVE (2008). Deforestation
was catalysed by the various droughts, and famine cycles in tandem with high unemployment and poverty levels which compounded deforestation and the stumps of the remnants of trees became a lucrative in the processing of charcoal and fuel wood hence contributing further to the decimation of the forest.

Table 9: View of respondent on the major driving forces for forest covers change

<table>
<thead>
<tr>
<th>No</th>
<th>Perception of Respondents to LU/LC Change</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fire</td>
<td>37.1</td>
</tr>
<tr>
<td>2</td>
<td>For production of charcoal</td>
<td>71.4</td>
</tr>
<tr>
<td>3</td>
<td>Agricultural Land expansion</td>
<td>54.3</td>
</tr>
<tr>
<td>4</td>
<td>Logging &amp; construction wood</td>
<td>25.7</td>
</tr>
<tr>
<td>5</td>
<td>Fire wood</td>
<td>17.1</td>
</tr>
</tbody>
</table>

Source: Field Study (N=70)

Major activities responsible for the loss of vegetation in the study area were expansion of agricultural lands, fuel wood and charcoaling (ARDO, 2010). Table 10 below depicts that environmental degradation in terms of conversion of one form of land use/land cover to the other. The forest land in the study area was decreasing continuously since 1973; it was supposed to be changed partly to charcoal production and construction and fuel wood, for sale of lumbering and agriculture land.

According to key informants the need is increased indirectly due to variability of climatic parameters mainly rainfall variability impact which decreases the productivity and production by erratic rainfall, recurrent drought, flooding, and product damage during collection by untimely rainfall. Here the key informants tried to show that the variability of rainfall resulted in the decrease of agricultural production and productivity so that they as an option tried to expand agricultural land to increase their production. So, this indicates the variability of climatic parameters indirectly forcing agricultural land expansion. This is Similar to Ojima et al. (2003), underlying (or indirect or root) causes are fundamental forces that underpin the more proximate causes of land-cover change. These indirect causes may
originate from the regional districts, provinces, or country or even global levels. They are often exogenous to the local communities managing land and are thus uncontrollable by these communities (Vancker & Govers 2003).

Table 10: Comparison of Estimation of conversion rate of land use/land covers dynamics

<table>
<thead>
<tr>
<th>Duration</th>
<th>LU/LC conversion rate (ha/yr)</th>
<th>Bush</th>
<th>Forest</th>
<th>bare</th>
<th>Grass Land</th>
<th>Fallow land</th>
<th>Cultivated land</th>
<th>Mixed land</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973/1986 (13yrs)</td>
<td>-253</td>
<td>-291</td>
<td>+76.2</td>
<td>220.82</td>
<td>382.14</td>
<td>+954</td>
<td>10.52</td>
<td></td>
</tr>
<tr>
<td>1986/2000 (14yrs)</td>
<td>-243</td>
<td>-177</td>
<td>-242</td>
<td>-621</td>
<td>-348</td>
<td>+728</td>
<td>-175</td>
<td></td>
</tr>
</tbody>
</table>

*Source: GIS processing. + Increment, - decrement*

Farmers in the study area diversified on-farm activities (in terms of crop-livestock mix and crop diversity) to spread risks mainly against climate hazards and to meet consumption needs. Farmers characterized the rainfall in the area as highly irregular, inadequate, showing poor seasonal distribution, or a combination thereof. Therefore, they diversified their crops rather than depending only on annual crops they plant to drought resistant fruits such as Mango, Papaya, Halako (Moringa Olifera) as capage, cassava widely planted in every farmer’s garden as guarantee of food insecurity especially in the drought prone lowland of the study area. The farmers also diversified the livestock types from poultry production to cattle production in assumption that when one type of it is affected by drought, they relied on other resistant ones. Much of the benefit they made from these activities is to buy food grains and cover the cost of cloth, school materials for their children and annual tax for their land. The local people also developed off-farm and non-farm income generating activities as climate change impact coping mechanisms (Figure 11).
Key informants revealed that the degree of focus increased on cottage industries and petty trades – specialized handicrafts such as weaving, pottery, poultry, local *Shisha (gaya)* preparation. It is smoking material and chemical from tobacco which locally developed and sold in the market. Then there is also locally developed non-ruminant animals supported two wheels pulling vehicles used to transport small materials to market for merchants and generate some incomes for households. Other indigenous coping mechanisms valuably used as preferred options in uncertainties of rainfall for short and long term basis are represented in table 11 below.

This agreed with different studies (Dessalegn 1991; Webb & Braun 1994; and Markos Ezra 1997) that found that peasants engage in coping strategies during food insecurity that involved the lowering of food consumption and quality, shifting to non-farm income sources, greater
dependency on kin and relation as source of gift. In this case the household members which are in good physical condition, mainly young people, reduce meal time from three times a day in normal conditions to two times a day. The children and old aged household members are not required to do this.

Table 11: Adaptive strategies of households for food shortage during uncertain rainfall

<table>
<thead>
<tr>
<th>No.</th>
<th>Suggested response in uncertain rainfall season</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selling of cattle</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>Reducing expense</td>
<td>51</td>
</tr>
<tr>
<td>3</td>
<td>Labor migration</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>Reducing consumption</td>
<td>53</td>
</tr>
<tr>
<td>5</td>
<td>Eating of optional food</td>
<td>38.6</td>
</tr>
</tbody>
</table>

Source: Field Study (N=70)

During household surveys, respondents also pointed out that they ate optional food or previously inedible food in normal conditions. In this case, the local people has been eating low quality foods to sustain their lives due to food shortages and droughts or delayed rainfall seasons. During drought years they ate unusual food from the forest locally known as: ‘Umbeleta leaf’ (Entadopsis sudanica), ‘Kega’ (Rosa abyssinica), ‘Ladiya’ (Acanthera schimperi), ‘Astiya’, ‘Dokima’, and ‘Lagicho’.

To reduce the stress caused by the shortage of pasture for the livestock due to recurrent droughts, households practiced use of straw, hay and reduce livestock numbers. With severe droughts and other climate related risks, households in the study area have become increasingly under pressure to sell or exchange their livestock. About 57% of the respondents described an increasing trend of livestock selling due to shortage of pasture in rainfall delayed years since recent times. The measures taken by the farmers to care for their animals vary according to the locality and the severity of the problem. About 57% of the farmers use excess crops as fodder for their livestock to survive during droughts. They store the crops in
appropriate containers with the expectation drought occurrences in upcoming months or years. About 25.4% of the farmers responded and said that they prepare hay when grass was in excess during the wet season with the expectation of uncertainty or delay of future Belg rainfall in coming seasons. Only 7% of the farmers purchased forage or grass from neighbouring people that have excess grass or forage but not livestock. About 24% of the respondents indicated that they also reduced their livestock in times of drought. They also moved them to pasture in areas where there are people without livestock. Poor households gain about half of the profit at the end rewarded by a share in the sales by keeping and fattening some of the richer families’ livestock. This was a means to reducing the number of livestock from feed shortage for relatively better economically positioned households and income generation for the poor in order to get some relief from food shortages during droughts.

The farmers also said that they have established social institutions such as Idir and Equb to help each other in times of personal crises. Idir is a territorially based voluntary association of peasants formed for mutual help and cooperation. The primary objective of Idir is to help member households with monetary or materials resources in times of difficulties such as the death of a member of households, loss of property, accidents, and the like. In order to achieve this objective, peasants get membership in the Idir by paying a membership fee. The Equb is also a voluntary association that provides rotating credit services for members. It is used mostly when a given individual wants initial capital for mini-trading as source of income for survival or as incentive funding for small business activities. Unable to get the capital by their own they form a group and decide on a given amount of money to be collected for group members rotationally. Idir and Equb significantly contribute to the welfare of members of the institutions. They are helped to cope with the challenges of food security which was mainly caused by variability in rainfall patterns. The Equb especially helps those young household members to minimize their dependence on agriculture and diversify their livelihood.

Conclusion
Analysis of historical climate data in terms of temperature and rainfall patterns in the study area revealed that there has been increased variability during the last three decades with greater variation in rainfall and
temperature. As it has been observed, rainfall showed a slight increasing trend for total annual rainfall over this period. However, the Belg rainfall which contributes a larger portion of annual crop production of the study area showed a declining trend and high variability. The Meher rainfall which contributes small amounts of average annual crop production of the study area indicated a slight increasing trend. Average monthly annual temperature showed a slight declining trend with high variability. Although drought was a common phenomenon in the study area, it has become more frequent and intense in magnitude in recent years. The drought cycle has become shorter and droughts prevailed almost every year or two years in recent years.

The impacts of climate change ranges from crops and livestock’s yield reduction through time to impact on agro-biodiversity. The reduction of agricultural production due to climate change forced the local people to depend highly on forest resources for firewood and charcoal production, which they sell in nearby towns. They do this because they need the money to purchase food grains and expand their agricultural production. This in turn results in land use, and land cover change at an alarming rate. It also affected the land use and land cover change of the study area over the last three decades. Local people developed local adaptation strategies such as on-farm, off-farm and non-farm livelihood diversification, reducing the number of livestock in seasons of low or late rainfalls, and helping each other with social institutions during times of scarcity and hazard. They also use drought foods which they do not normally use.

Recommendations

- The early warning system of the study area should be comprehensive and should include existing and new types of disasters protection with improved coordination and dissemination of relevant information.
- Land management activities should be encouraged in a way that can reduce flood damage and limit soil erosion at times of intensive erratic rainfalls.
- Climate data that has a fairly good temporal resolution and spatial coverage would considerably contribute to understanding the study area. Improved coverage and quality of climate data in the study area in particular and in the country in general should be available in order to enhance the understanding, analysis and prediction of climate change and its impacts for improved preparedness and adaptation.
For minimizing dependence only on rain-fed agriculture, there should be water management practices and irrigation agriculture developed using the opportunity of Bilate River which is a perennial river and crosses the Woreda and Lake Abaya which is in the southern border of the study area.

Early maturing, drought tolerant crops and highly productive varieties of crops should be introduced in the area in order to increase crop production and reduce the impact of unreliable rainfall on food insecurity.

The farming with cash crops which are resistant to climatic variability and already introduced in a few areas – cotton, mango, and papaya for instance – should be widely encouraged in the area. This can improve household incomes and reduce the dependence on forest resources in the area.

Interventions need to build on strengthening indigenous knowledge and local coping strategies in order to ensure sustainability of life.

Information on some local coping strategies which are being practiced by some people should be widely disseminated in the entire community together with technical and material support.

Further research should be conducted on the local level impacts of climate change in order to identify specific problems in each sector with regard to the livelihoods of the communities so that responses can be more target orientated.

References


**Contributor Information**

Shemsedin Ahmed, University of Addis Ababa, Ethiopia.
Contributors

Ernest Nti Acheampong
International Water Management Institute (IWMI), Accra, Ghana

Mesfin Kassa Admassie
Population, Health and Environment Ethiopia Consortium, Bole Medahniyalem Church, Addis Ababa, Ethiopia

Moses Solomon Agwaya
Natural Chemotherapeutics Research Institute, Ministry of Health, Kampala, Uganda

Shemsedin Ahmed
University of Addis Ababa, Ethiopia

Juliet Gwenzi
Department of Physics, University of Zimbabwe

Elisha Felician
Sokoine University of Agriculture (SUA) Forestry and Nature Conservation Department

Thabit Jacob
Institute of Natural Resource Management, University of Dar es Salaam, Tanzania

Hassan O. Kaya
University of Kwazulu-Natal, Durban, South Africa

Samuel Kimani
Kenyatta University, Nairobi, Kenya
Contributors

Ruth Magreta
Department of Agriculture and Applied Economics,
Bunda College, University of Malawi

Henry Massa Makuma
Makerere University, Department of Agriculture and Environmental Sciences, Uganda

Kassim Ramadhani Mussa
Dar es Salaam, Tanzania

Eliud Magu Mutitu
Institute of Plant Protection, 8360 Keszthely Festestic Str. Ut 5, Hungary

Grace Kyeyune Nambatya
Natural Chemotherapeutics Research Institute,
Ministry of Health, Kampala, Uganda

Jacquiline Nassali
Department of Biology, Makerere University, Uganda

Francis Omujal
Natural Chemotherapeutics Research Institute,
Ministry of Health, Kampala, Uganda

Roxventa A. Ongugo
Kenyatta University, Nairobi, Kenya

Yonah N. Seleti
Indigenous Knowledge Systems Office
Department of Science and Technology, South Africa

Mpho Setlalekgomo
Botswana College of Agriculture, Botswana

Henry Ralph Tumusiime
Natural Chemotherapeutics Research Institute,
Ministry of Health, Kampala, Uganda
Jean-Philippe Venot
International Water Management Institute (IWMI),
Accra, Ghana

John. N. Wanjau
Kenya Institute of Organic Farming (KIOF), Juja, Kenya

Anke Weisheit
Mbarara University of Science and Technology,
Mbarara, Uganda