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AfricaInteract: Enabling research-to-policy dialogue for adaptation to climate change in Africa

Review of Research and Policies for Climate Change Adaptation in the Agriculture Sector in East Africa

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AfricaInteract is funded by the International Development Research Centre (IDRC) and coordinated by the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) under the auspices of the Forum for Agricultural Research in Africa (FARA). The regional focus of *AfricaInteract* is based on the Regional Economic Communities in the four sub regions of sub-Saharan Africa. Focal organizations coordinating regional activities are as follows: The Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) – East Africa; Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) – Southern Africa; Commission des Forets d'Afrique Centrale (COMIFAC) – Central Africa; and Energie-Environnement et Developpment (Enda) – West Africa.

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Acronyms and abbreviations

APRM	African Peer Review Mechanism
CA	Conservation agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
EAC	East African Community
EACCCP	East African Community Climate Change Policy
GDP	Gross domestic product
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
MDG	Millennium Development Goal
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organisation
SSA	Sub-Saharan Africa
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

Climate change is rapidly emerging as major risk factor affecting the agriculture sector across the East African region. It poses a serious risk to development, especially in developing countries due to their dependence on climate sensitive economic sectors such as rain-fed agriculture (IPCC 2007). Accordingly, Africa is regarded to be highly vulnerable to recurrent droughts, and this vulnerability is aggravated by factors such as widespread poverty, inequitable land distribution and low technological capabilities. Climate change is expected to challenge the adaptive capacities of many different communities, and overwhelm some, by exacerbating existing problems of food insecurity and water scarcity (Brown 2007). This paper aims at synthesising research and policies related to climate change adaptation in the agricultural sector in Africa, with a particular focus on the East African region.[1]

The review was based on a detailed literature search with a focus on performance of the agricultural sector within the East African region. The literature search involved collection of peer reviewed literature, government, donor agency and NGO reports and other 'grey literature' regarding the status of agricultural production in the region, including an analysis of climatic issues and other challenges influencing this sector within the Eastern African region. The review used information from journal articles and other relevant publications pertaining to climate change adaptation within the agricultural sector in respective countries within the East African region. Most of the articles were published from the year 2000 to date. The countries' National Adaptation Programmes of Action (NAPAs) were also among the documents consulted to examine how well they have addressed agricultural issues with regard to adaptation to climate change and variability.

Overview of key findings

The impacts of climate change on the agricultural sector vary depending on the existing agro-ecological zones. The East African region exhibits considerable climatic and topographic variability. Much spatial and temporal variation in the response of different crops to climate change can thus be anticipated. The review identified that farming systems in East Africa comprise a diversity of crops such as cereals, root and tuber crops, legumes and oil crops. The vast majority of farming systems in East Africa are rain-fed and only a small area is irrigated. From various researches conducted in the region to date, it has been reported that agriculture plays a dominant role in spurring growth and getting large numbers of people out of poverty. It is thus a principal route to meeting the Millennium Development Goals. Agriculture is to be considered more than simply an economic activity: it is a key for food security and thus for survival; a means of livelihood and culture; and a provider of environmental services. Smallholder subsistence agriculture with its specific roles of farmers is intimately intertwined with rural ways of life.

Climate change is set to hit the agricultural sector the hardest and cause untold suffering, particularly for all categories of smallholder farmers. The various studies so far conducted in the East African region indicate that smallholder farmers have observed changes in the amount and distribution of precipitation, associated with increases in temperature. Farmers' responses have included using short season drought-resistant crops, employing irrigation, adjusting planting dates and planting trees to adapt to the potential negative impacts of climate change on their agricultural yields. Although the potential to invest in irrigation in much of Africa is high, poor performance of large-scale irrigation schemes and competition for diminishing water resources suggest that smallholder irrigation is preferable. Conservation agriculture (CA)[2] has been reported as among the 'climate smart agriculture' strategies, as it promises relief in the changing climate. Among other benefits, if well managed, conservation agriculture helps foster agro-biodiversity and other essential environmental services, which improve agro-ecosystem resilience, helping farmers to better face risks and uncertainties as a result of climate change.

Furthermore, raising livestock on drylands through seasonal migration is seen as an efficient way to make use of lands that are unsuitable for other forms of agriculture. Rangeland resources are typically heterogeneous and dispersed, with their variation tied to seasonal patterns and variable climatic conditions. Many researchers studying pastoral systems have concluded that extensive livestock production on communal land is the most appropriate use of semi-arid lands in Africa. However, pastoral communities remain among the most politically and economically marginalised groups in many societies.

Overall conclusions and recommendations

Agricultural research is a crucial area for adaptation to climate change in order to deal with changes in the length of growing seasons, increased droughts and periodic waterlogging as well as increased temperature and salinity. National Agricultural Research Centres and the private sector in areas expecting more droughts in future should be supported to contribute to agricultural adaptation, taking on board climate smart agricultural practices. Despite past and ongoing initiatives, the region lacks strong policies that can provide for implementation of the necessary climate change adaptation strategies so far researched. Some of the existing policies and frameworks, such as the East African Community Climate Change Policy (EACCCP), are not yet felt at the grassroots. The framework aims at guiding the East African region's strategies to urgently respond to the adverse impact of climate change that includes addressing the challenge of food insecurity as a result of the extreme climatic conditions associated with climate change; including deepening cooperation among partner states. Given differentiated impacts of climate change on women, men and youths, and the roles of women specifically in addressing climate change, gender considerations, with

respect to vulnerability and adaptive capacities within the agricultural system, have been given attention. Apparently, the agricultural and other sector policies in East Africa do not adequately provide for climate adaptation strategies, which has been a major limitation in strengthening climate change adaptation in the region.

Integrated approaches are also needed in development interventions aimed at promoting adaptation to climate change. Smallholders are exposed to global environmental change and economic globalisation leading to competition between smallholder produce and highly subsidised produce from industrialised countries. There is a need to examine the trade-offs and synergies between international climate and trade policies as these can impede or enhance adaptations. This means that any introduced adaptation measures should be tested through the whole chain from smallholder producers to consumers to ensure that adaptation practices are really providing layers of resilience against climate change.

Combining local and scientific knowledge systems is important for making climate information relevant locally and for empowering communities. Local adaptive capacity is enhanced by including communication and use of climate information in adaptation planning processes, enabling communities to live with the uncertainty and risks that climate change presents. CA, among the climate smart agricultural strategies, appears to have potential in strengthening climate change adaptation. CA is claimed to be a panacea for the problems of poor agricultural productivity and soil degradation in sub-Saharan Africa. It is thus actively promoted by international research and development organisations. CA is reported to increase yield, reduce labour requirements, improve soil fertility and reduce soil erosion. According to some studies, however, there are concerns regarding the practicality of CA, which contributes to its low uptake in most of the region's countries. These concerns include decreased yield, increased labour requirement and an important shift of the labour burden to women. However, empirical studies are needed in different agro-ecological zones to test CA's contribution to adaptation planning. The respective governments are called upon to provide the resources required for CA interventions to meaningfully support food security and rural livelihoods. This entails ensuring that adequate and balanced financial allocations are made for conservation agriculture projects. This further calls for critical assessment of the ecological and socio-economic conditions under which CA is best suited for smallholder farmers in the region.

Empirical studies on gender also need to be conducted in different agro-ecological zones to test its contribution to adaptation planning. The donor community is called upon to provide the resources required for ecological agriculture interventions to meaningfully support food security and rural livelihoods. This entails ensuring that adequate and balanced financial allocations are made for ecological agriculture projects.

1 Introduction

1.1 Background and motivation

While there is undisputed evidence that the climate is changing, there is a lot of uncertainty regarding the pace and extent of the change, and the different impacts on the sub-Saharan regions, sectors, nations, and communities. This uncertainty renders policy decision-making more complex and magnifies the need for Africa to build its knowledge and analytical base and to strengthen the capacity of country and regional institutions in developing the evidence base needed to address climate change adaptation issues. At present, virtually all countries on the continent have performed some stock-taking of the variability and change in the climate and of the impact of those changes on livelihoods. The Least Developed Countries (LDCs) in Africa have been supported by the United Nations Framework Convention on Climate Change (UNFCCC) to undertake National Adaptation Programmes of Action (NAPAs); while all remaining countries have, to varying degrees, pursued climate change adaptation measures on their own. For example, the NAPA documents for Tanzania, Uganda, Rwanda and Burundi have highlighted a number of priority areas in support of climate change adaptation. The priority areas include improving food security in drought prone areas by improving water availability and by using drought tolerant crops, integrated water resource management, seasonal early warning, land use plans, intensive livestock grazing, emphasis on indigenous knowledge (IK) and supporting non-agricultural income generating activities, among other priority areas. Besides the fact that most NAPAs are generally viewed to have been inadequately designed and implemented, a regional perspective of climate change adaptation is yet to be fully realised. Thus with the climate changing, the continent's vulnerability is deepening, making it the most exposed region in the world to the impacts of climate change (World Bank 2008. As a result, food and water security, livelihoods, shelter and health are all at risk.

There is growing research interest in and support for adaptation to climate change in Africa. It is thus imperative that the findings emerging from relevant research are applied and used to inform policymaking with regards to climate change adaptation. Thus, this review is part of an effort to fill this gap. It is critical that the sector policies are appropriately informed by the existing body of knowledge on climate change and climate variability generated from scientific research. These policies should enable the respective sectors to build resilience against climate change and climate variability through adequate adaptation strategies and contribute to mitigation of climate change through use of improved and innovative technologies and management practices.

This review aims to help by identifying gaps in research and policymaking for climate change adaptation in the agricultural sector. It further provides information and insights that can be used to bring researchers and policymakers together to improve evidence-based policymaking that can enhance food security and protect different categories of populations vulnerable to climate change. The review focuses on analysis of the agricultural sector in the context of climate change within the East African countries, particularly Kenya, Tanzania, Uganda, Burundi and Rwanda. Some reflections also cover Ethiopia in the Eastern Horn of Africa.

1.2 Key questions guiding the review

The review was guided by the following key questions:

1. What is the role of climate change challenges in the context of the multiple challenges and opportunities facing the agriculture sector in the region?

2. What is the current state of knowledge on adaptation to climate change in the agricultural sector in the region?

3. What is the current state of knowledge on whether and how research findings are integrated in agriculture sector policies in the region?

4. What are the major gaps in research on adaptation to climate change in the agricultural sector?

5. What is needed to ensure that research findings are better integrated into agriculture sector policies?

6. What is the current state of knowledge on the stakeholders involved with research and policy on adaptation to climate change in the agricultural sector in the region, and how could stakeholder involvement be improved?

1.3 Outline of the paper

This paper is divided into nine main sections. Section 1 is the introductory chapter and this presents the background, motivation and key questions guiding this review with a consideration of cross-cutting issues. Section 2 presents the methodology section, with a highlight on definition of key concepts and providing an elaboration of how the review work was undertaken. Section 3 provides an overview of the agriculture sector in the region, the role of climate change challenges and the state of knowledge on the implications of climate change for other key challenges and opportunities for the sector in the region. Section 4 discusses the key findings based on climate adaptation research in the agriculture sector within the East African region with a particular focus on assessment of vulnerability and adaptation of crop farming systems, livestock, pastoralist systems and fisheries in the region. Section 5 presents and discusses agricultural policies for climate change adaptation in the region from a historical perspective, also capturing experience on previous and ongoing policy initiatives within the East African region; special emphasis is also made on the East African Community (EAC). Section 6 highlights some gaps in climate change adaptation research and policy in the agricultural sector. An analysis of stakeholders and opportunities for collaboration with regard to climate change adaptation research and policy is presented in section 7. This section also provides a synthesis of key institutional actors and lessons to promote research-policy dialogues on adaptation in the agriculture sector within the East African region. Finally, conclusions and recommendations based on the review of the key findings are presented in section 8.

2 Methodology

2.1 Scope of review

The review was commissioned to meet one of the expected outputs of the *AfricaInteract* project, funded by the International Development Research Centre (IDRC) and coordinated by the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) in collaboration with the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA).

The review covers East Africa, with a particular focus on Tanzania, Uganda, Kenya, Burundi, Rwanda and Ethiopia. It focuses on the analysis of the agricultural sector in terms of climate change adaptation research and policy. Based on the Terms of Reference, the key tasks related to the review are outlined as follows:

Task 1: Review climate change adaptation research and policy pertaining to the agricultural sector in a specific sub-region (East Africa – comprising, Tanzania, Kenya, Uganda, Burundi and Rwanda)

Task 2: Identify gaps in (a) climate change adaptation research and policy in the agricultural sector, and (b) the way research informs policymaking

Task 3: Identify key stakeholders and opportunities for improving climate change adaptation research-policy nexus in the agricultural sector

Task 4: Prepare an overall report comprising three sub-reports corresponding to each of the preceding 3 tasks

2.2 Key definitions

Coping versus adaptation to climate change

Coping strategies are invoked following a decline in 'normal' sources of food, and these are regarded as involuntary responses to disaster or unanticipated failure in major sources of survival (Ellis 2000). The term 'coping' is usually applied to short-term measures used by farmers who experience a loss or reduction in their direct access to food when harvests fail, or to workers who, for whatever reasons, lose their employment and income and therefore face the threat of hunger or even starvation. The term is also used to refer to the ways in which people deal with seasonal food stress (Foeken and Hoorweg 1988). It should however be noted that there are overlaps between coping and adaptation in the sense that coping may lead to adaptation.

Adger et al. (2007: 869) define adaptation as 'an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'. Various types of adaptation can be distinguished, namely, anticipatory, autonomous and planned adaptation:

- Anticipatory (proactive) adaptation takes place before the impacts of climate change are observed.
- Autonomous adaptation does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
- Planned adaptation is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state (adapted from IPCC 2007: 869).

While adaptation to environmental variability has been studied since 1900, scholars began to use the term adaptation for the study of the consequences of human-induced climatic change in the 1990s (Adger et al. 2005). Adaptation is generally perceived to include a long-term adjustment in social–ecological systems in response to actual, perceived, or expected environmental changes and their impacts. Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realise new opportunities. Adaptations include anticipatory and reactive actions; private and public initiatives; and can relate to projected changes in temperature and current climate variations and extremes that may be altered with climate change. In practice, adaptation tends to be an ongoing process reflecting many factors or stresses, rather than discrete measures to address climate change specifically (Adger et al. 2007).

Vulnerability and vulnerability assessment

Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change (Füssel and Klein 2006). The term 'vulnerability' may therefore refer to the vulnerable system itself, e.g. low-lying islands or coastal cities; the impact to this system, e.g. flooding of coastal cities and agricultural lands or forced migration; or the mechanism causing these impacts. Many impacts, vulnerabilities and risks merit particular attention by policymakers due to characteristics that might make them 'key'. Key impacts that may be associated with key vulnerabilities are found in many social, economic, biological and geophysical systems, and various tabulations of risks, impacts and vulnerabilities have been provided in the literature (e.g. Smith et al. 2001).

With regard to vulnerability of societal systems, there are myriad thresholds specific to particular groups and systems at specific time frames beyond which they can be vulnerable to variability and to climate change (Yamin et al. 2005). These differences in vulnerability are a function of a number of factors. Exposure is one key factor. For example, crops at low latitudes will have greater exposure to higher temperatures than crops at mid- and high latitudes. Thus, yields for grain crops, which are sensitive to heat, are more likely to decline at lower latitudes than at higher latitudes. Social systems in low-lying coastal areas will vary in their exposure and adaptive capacities, yet most will have increased vulnerability with greater warming and associated sea level rise or storm surges. A second key factor affecting vulnerability is the capacity of social systems to adapt to their environment, including coping with the threats it may pose, and taking advantage of beneficial changes. Smith et al. (2001) identified a number of determinants of adaptive capacity, including such factors as wealth, societal organisation and access to technology (see also Yohe and Tol 2002). These attributes differentiate vulnerability to climate change across societies facing similar exposure.

Resilience

Resilience is employed in various fields such as ecology and sociology, among others. Ecologists conceptualise resilience in analysis of population ecology of plants and animals, including in the study of ecosystem management. In sociology, resilience is mainly used in reference to social-ecological systems (Janssen et al. 2006; Holling 1973). Generally, the initial conceptualisation of resilience was dominated by empirical observations of ecosystem dynamics interpreted in mathematical models (Folke 2006). However, since the late 1980s,

there has been a shift from this conceptualisation and resilience has increasingly been used in the analysis of human-environment interactions, mainly to describe and understand how humans affect the resilience of ecosystems. Moreover, there are now serious attempts to integrate the social dimension in resilience work. These efforts are reflected in the large numbers of sciences involved in explorative studies and new discoveries of linked social-ecological systems (Folke 2006).

In some studies, resilience is regarded as the opposite of vulnerability (Folke et al. 2002), while in others this distinction is not so clear (Gallopín 2006; Adger 2000). It is however important to note that resilience and vulnerability are not always two sides of the same coin: under different circumstances (time, context), a resilience factor can exacerbate vulnerability to climate change. For example, keeping livestock can be a resilience factor under non-drought and the early stages of drought, as livestock can be sold for income. However, under advanced drought conditions, holding onto livestock increases vulnerability to drought impacts (Speranza 2006).

Agriculture sector

Agriculture is the industry or practice of humans purposefully growing crops or raising livestock for the production of foodstuffs that they can consume directly, or they can consume after some process, or they can feed to other livestock/organisms that can themselves be consumed directly or through some process. The agriculture sector in the context of this review refers to crop farming (including use of forest products for adaptation), livestock (including pastoralism and crop-livestock systems) and fisheries. Concerns about sustainability in agricultural systems centre on the need to develop technologies and practices that do not have adverse effects on environmental goods and services; are accessible to and effective for farmers; and lead to improvements in food productivity. 'Ecological farming' is recognised as the high-end objective among the proponents of sustainable agriculture. The goal of ecological farming is not only sustainable food production, but to optimise the provision of ecosystem services. In relation to this, application of conservation agriculture (CA) is gaining acceptance in many parts of the world as an alternative to both conventional and to organic agriculture. CA is based on principles of rebuilding the soil; optimising crop production inputs, including labour; and optimising profits. CA is the integration of ecological management with modern, scientific agricultural production.

2.3 The approach of the review

This review was based on a detailed literature search on relevant issues with regard to climate change and the performance of the agriculture sector within the East African region in terms of challenges and opportunities. The literature search involved collection of peer-reviewed literature, government, donor agency and non-governmental organisation (NGO) reports and other 'grey literature' regarding the status of agricultural production in the region, including an analysis of climatic issues and other challenges influencing this sector in the region. The review focused on evidence-based information from journal articles and other relevant publications pertaining to climate change adaptation within the agricultural sector in respective East African countries. The countries' NAPAs were also considered among other important documents to examine how well they have addressed the agricultural issues with regard to adaptation to climate change and variability. The content analysis of issues was undertaken based on the review of various country and regional documents, whereby key questions as per the Terms of Reference guided the review work. The review also looked at gender issues within the agricultural sector in a changing climate. Apparently relatively few analyses have been done regarding gender and agriculture in the context of climate change. It is therefore vital to take note of the need to address gender perspectives in all aspects of climate change. Gender inequalities in access to resources, including credit, extension services, information and technology should be taken into account in adaptation efforts.

2.4 Potential limitations and challenges

The review was mainly based on deskwork, and therefore lacked some interviews with relevant experts in various countries within the region. However, since collection of literature also reflected all the countries in East Africa, this sufficed to provide evidence of what is happening in the agricultural sector in the various countries. In some countries, such as Burundi and Rwanda, apart from NAPA documents and a few research reports it appeared that there is inadequate scientific research done with respect to climate change and its implications on the agricultural sector. In this case the consultant reviewed other relevant reports that reflected on these issues.

3 Overview of agriculture in the East African region

3.1 The status of the agricultural sector in the region

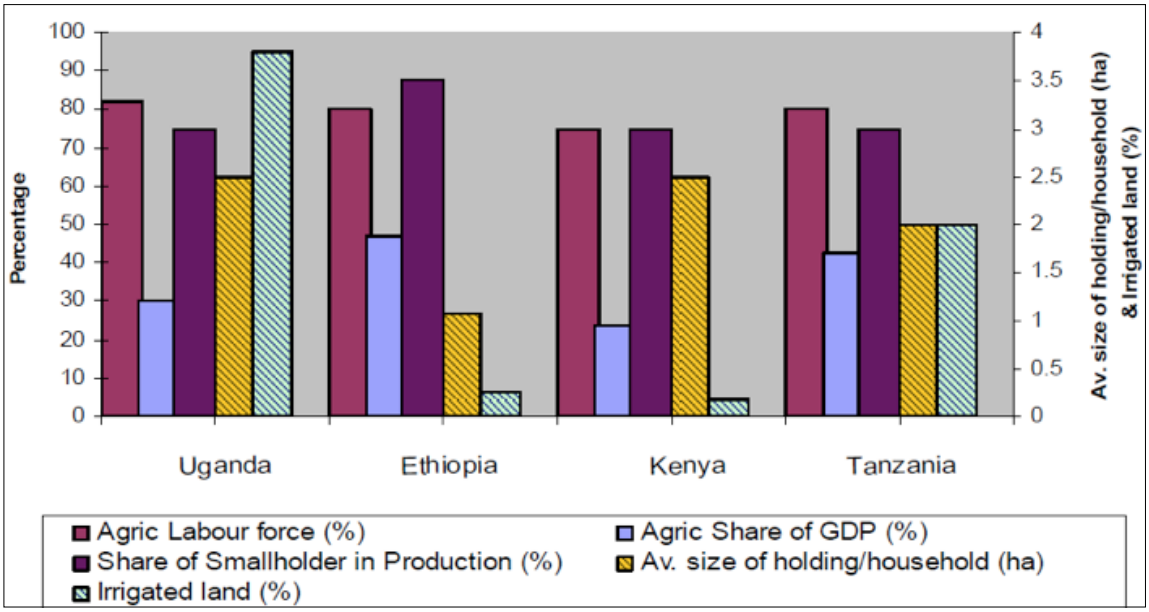
Agriculture plays a dominant role in most African societies. Despite its current weaknesses, it is a key for spurring growth and getting large numbers of people out of poverty, and is a principal route to meeting the Millennium Development Goals (MDGs) (Zimmermann et al. 2009). All MDGs have a gender dimension, and gender equality is indispensable for achieving all of them. Agriculture is to be considered more than simply an economic activity – it is a key for food security, and thus for survival; a means of livelihood and culture; and a provider of environmental services for various categories of population. In sub-Saharan Africa (SSA), agriculture currently accounts for about 30 percent of gross domestic product (GDP), at least 40 percent of export value and approximately 70-80 percent of employment (World Bank 2009; 2007a; FAO 2006; IMF 2006). Based on its importance to the livelihoods of the poor, the World Bank pointed out in its 2008 World Development Report that there is need for devotion to agriculture and rural development, and that the sector must be placed at the centre of the development agenda if the MDGs of halving extreme poverty and hunger by 2015 are to be met (World Bank 2009).

In sub-Saharan Africa more than 75 percent of the total population live in rural areas, and the majority of them are smallholder households involved in agricultural activities (ILO 2007; FAO 2006). Population increases of nearly three percent a year since the mid-1940s, however, have made it difficult to maintain soil quality and increase production using these extensive techniques. Declining fallows lead to various forms of land degradation: the soil fertility of cultivated land is no longer able to regenerate naturally; farmers are pushed onto marginal, environmentally fragile lands; and vegetative cover, which protects soil against erosion, progressively disappears. The status of agriculture and economic contributions of the agricultural sector in East Africa are illustrated in Figure 1.

The vast majority of farming in East Africa is rain-fed, and only a small area is irrigated (Rosegrant et al. 2002). Farming systems in East Africa comprise a diversity of crops such as cereals, root and tuber crops, legumes and oil crops. Cereals are a very important component of the agricultural production system both in semi-arid and sub-humid areas. The main cereal crops include maize, millets and sorghum. The main root crops are cassava and sweet potatoes. The leguminous crops include beans and cowpeas. Seventeen distinct farming systems have been identified in Africa (IAC 2004): maize-mixed, cereal/root crop mixed, root crop, agro-pastoral millet/sorghum, highland perennial, forest based, highland temperate mixed, pastoral, tree crop, commercial-large holder and small-holder, coastal artisanal fishing, irrigated, rice/tree crop, sparse agriculture (arid), urban based, highland mixed, and rain-fed. Virtually all of these systems are practiced in East Africa to varying extents.

Most of the East African farming systems are characterised by weathered soils of low inherent fertility and high fragility; by declining soil fertility due to population growth and a minimal use of external inputs; and by highly variable rainfall – especially in the drier rain-fed systems (Ibid). For the foreseeable future, multiple farming systems must become more productive to generate the increases in food necessary

Figure 1. Status of agriculture and economic contribution in East Africa



Source: AfDB (2009) and FAOSTAT (www.faostat.fao.org)

Table 1: Livestock production systems in Africa

Abbreviation	Animal production system	Agro-ecological zone
LGA	Pastoral, livestock only, rangeland-based	arid/semi-arid
LGH	Pastoral, livestock only, rangeland-based	humid/subhumid
LGT	Pastoral, livestock only, rangeland-based	temperate/tropical highland
MRA	Agro-pastoral, mixed rainfed	arid/semi-arid
MRH	Agro-pastoral, mixed rainfed	humid/subhumid
MRT	Agro-pastoral, mixed rainfed	temperate/tropical highland
MIA	Agro-pastoral, mixed irrigated	arid/semi-arid
MIH	Agro-pastoral, mixed irrigated	humid/subhumid
LL	Peri-urban, landless	

Source: Perry et al. (2002). Includes both Sub-Saharan and North Africa.

to feed the hungry in the East African region, particularly in the context of climate change. The region also hosts a diversity of livestock production systems, as presented in Table 1. The East African countries cover the pastoral, agro-pastoral and mixed rain-fed types raging from the semi-arid to sub-humid tropical highlands. There is inadequate documentation of the impact of climate change in each of the agro-ecological zones; this is a gap which needs to be addressed.

3.2 State of knowledge on climate change and impacts on the agricultural sector

The African continent is experiencing a general warming trend, with certain regions warming more than others (Boko et al. 2007). The warming is at approximately 0.5˚C per century since 1900 (Hulme et al. 2001). Accordingly, temperature projections for East Africa indicate that the median near-surface temperature in the 2080–2099 period will increase by 3-4°C compared to the 1980–1999 period. It has to be noted that this increase is about 1.5 times the projected global mean response. Averages of precipitation projections for East Africa, however, quite clearly indicate an increase in rainfall for East Africa for the 2080–2090 period. The changes in precipitation are likely not to be uniform throughout the year, but will occur in sporadic and unpredictable events. It is estimated that the number of extreme wet seasons in East Africa in the 2080–2099 period will increase from about five percent to about 20 percent (Seitz and Nyangena 2009). It should however be noted that precipitation is also highly variable across the continent, although much of the continent has experienced decreases in annual precipitation. An increase in inter-annual variability has been noted with the indication that extreme precipitation events (floods and droughts) are on the rise (Boko et al. 2007). Notwithstanding the inconsistency of predictions about climate change, the effects of the phenomenon are being experienced throughout SSA, especially in areas typified by variable rainfall shifting growing seasons (IPCC 2001). Most African farmers, particularly those working in rain-fed agriculture, have been affected in one way or another.

According to analysis of countries' NAPA reports, climate change is expected to increase the frequency and intensity of extreme weather events such as droughts, floods, landslides and heat waves in the East African region. Although rigorous and detailed vulnerability and adaptation options were not done for Uganda, the literature review analysis of empirical information shows that in Uganda the frequency of droughts has increased; for example, seven droughts were experienced between 1991 and 2000 (Government of Uganda 2007).

Climatic projections undertaken for Burundi and Rwanda (Baramburiye et al. 2013; Tenge et al. 2013) suggest that the countries' climate will become warmer (by 1-2.5°C). Furthermore, the CSIRO model projects that temperature increases for the entire country will be in the 1-1.5°C range. Given Burundi's tropical humid climate, this would imply high evapo-transpiration rates, reducing the water available for plant growth and other uses. Likewise in Kenya, recent studies that have considered projections of future climate change indicate future increases in mean annual temperature (average monthly temperatures) of broadly 1-3.5ºC over the range of models by the 2050s (2046–2065) (SEI 2009).

Projections of climate change in Tanzania expect a temperature rise of 2.2ºC by 2100, with higher increase (2.6ºC) in June, July and August. According to meteorological data, monthly temperatures over the last thirty years are already showing an upward trend (Government of Tanzania 2007). While literature states that rainfall is expected to continue to decrease in inner and dryland regions, coastal areas of Tanzania such as Dar es Salaam are predicted to receive increased rainfall during the rainy season. A detailed account of climate change trends and impacts in different sectors including agriculture in Tanzania is presented in its NAPA (Government of Tanzania 2007). Predictions show that the mean daily temperature will rise by 3-5 percent. Some areas of northern Tanzania will likely get wetter (by 5-45 percent), while others, especially in the south, will likely experience severe reductions in rainfall (up to ten percent). While rainfall is predicted to decrease by up to 20 percent in the inner parts of the region and the country, with dry seasons becoming longer and having

less rainfall, rainfall is predicted to increase by 30-50 percent in the coastal areas.

So far, all the climate models for the East African region show that rainfall regimes will change but these changes will vary with season and region. Most models project rainfall will increase on average, though some models project rainfall reductions in some months for some areas. Future predictions on extreme events (floods and droughts) vary much more widely. Many models indicate an intensification of heavy rainfall in the wet seasons, particularly in some regions, and thus greater flood risks. Droughts are likely to continue, but here too the projections are varied: some models project an intensification of these events, particularly in some regions, while other models indicate reductions in severity.

The range of models and results highlights a considerable uncertainty in predicting future effects, especially in relation to scenarios of future rainfall, floods and droughts, though also due to future socio-economic conditions and environmental services. Nevertheless, the analysis here does reveal potential areas of concern and helps focus priorities. Furthermore, it is essential to recognise this uncertainty, not to ignore it. There is a need to plan robust strategies to prepare for uncertain futures, rather than using uncertainty as a reason for inaction.

3.3 Challenges and opportunities within the agricultural sector in the context of climate change

The East African region exhibits considerable climatic and topographic variability. Much spatial and temporal variation in the response of different crops to climate change can thus be anticipated (Thornton et al. 2010). According to Moore et al. (2011), high spatial variability in yield is indicated for several key agricultural sub-regions of East Africa. It was furthermore established that the broad range of projected crop yields reflects enormous variability in key parameters that underlie regional food security; hence, donor institutions' strategies and investments might benefit from considering the spatial distribution around mean impacts for a given region. Ultimately, global assessments of food security risk would benefit from including regional and local assessments of climate impacts on food production.

In East Africa, climate variability may have devastating impacts on economies. Major droughts typically result in sharp declines in agricultural output along with related productive activity and employment. In turn, this will lead to lower agricultural export earnings and other losses associated with a decline in rural income, reduced consumption and investment and destocking (World Bank 1998). Significant droughts also have additional multiplier effects on the monetary economy, the rate of inflation, interest rates, credit availability, levels of savings, government budget deficits and external debt stocks. Of the top ten disasters in East Africa between 1970 and 2003, nine were caused by droughts (in 1969, 1979, 1980, 1984, 1989, 1990, 1992, 1999 and 2000). The greatest number of people affected by drought was in 1999–2000, totalling 4.4 million people in Kenya alone and about 14.2 million in other EAC countries (World Bank 2007). Many drought periods (1966–1970, 1979–1984, 1990–1992 and 1999–2000) in East Africa have been associated with the El Niño Southern Oscillation. Table 2 presents the implications of major droughts on GDP for the countries of the EAC.

Although the potential to invest in irrigation in much of East Africa is high, poor performance of large-scale irrigation schemes in the region and competition for diminishing water resources suggest that smallholder irrigation is preferable. When population grows rapidly, this leads to conflict over natural resources, especially water which is a limited resource in the first place, given erratic rainfall, droughts, seasonal shifts, shorter seasons and dry spells (Liwenga et al. 2012). Climate change and increasing population contribute to water scarcity and limit its availability for irrigation and other productive uses (Turner 2006).

Climate change and variability can impose additional pressures on water availability, water accessibility and water demand in the East African region. A regional analysis of climate change within the East African region shows that the supply and quality of water will both be affected (Seitz and Nyangena 2009). Changes in the physical and chemical aspects of lakes and rivers, like higher water temperatures, shorter periods of ice cover and decreases in river and lake ice thickness have

Table 2: Major drought years and changes in GDP in the EAC countries

Drought years	Rainfall deficiency in %	Agricultural GDP loss in %	GDP loss in %	Loss in export earnings in %
1970/71	15.2	0.50	0.07	17.00
1978/79	22.0	1.58	1.13	7.98
1980–1983	29.0	27.00	10.00	20.00
1990/91	10.2	(0.22)	0.43	17.50
1992–1994	11.9	3.64	(1.60)	(9.00)
1999/2000	7.0	11.18	1.44	(8.48)

Source: Seitz and Nyangena (2009); Figures in bracket are computed from Rainfall data and Country Accounts Bulletins)

been documented in recent decades. In East African lakes (Edward, Albert, Kivu, Victoria, Tanganyika and Malawi), deep-water temperatures, which reflect long-term trends, have risen by 0.2-0.7°C since the early 1900s (IPCC 2007). Inter-annual lake-level fluctuations and lake-level volatility have been observed in lakes including Tanganyika, Victoria and Turkana since the 1960s. This is probably due to periods of intense drought followed by increases in rainfall and extreme rainfall events in late 1997 (Riebeek 2006).

Despite the fact that the key livelihood activity is agriculture, a recent study examining rainfall, food security and human mobility in Tanzania indicated that amid increase in uncertainty in agriculture and high land pressure, non-farm activities will be the key elements of livelihood strategies for many youths in the future (Liwenga et al. 2012). The findings further established that climate variability causes short and long-term changes that result in water deficit affecting both crop and livestock production, and thus influence decisions to migrate. Accordingly, the preference of the youths has been for migrating to other areas, both rural and urban. Future destinations of migration included cities such as Dar es Salaam, Mwanza and Arusha. The migration pattern could be temporal or seasonal depending on the impacts of climate related events such as droughts.

Furthermore, research findings have established that agricultural biodiversity is central to human existence and in particular to climate change adaptation. Farmers, rural communities and indigenous people around the world maintain the diversity of crops, forages, livestock, tree species and fish, as well as the many other plant, animal and microbial species found in and around their production areas and depended on to provide food, fuel, medicine and other products (Rudebjer et al. 2008). Climate change, in combination with other drivers, is expected to substantially alter agricultural biodiversity (Chakeredza et al. 2009).

4 Climate adaptation research in the agricultural sector

The adverse impacts of climate change and variability being aggravated by increasing average global temperatures are a threat to the livelihoods of people in almost all sectors of the economy in East Africa. Severe droughts, floods and extreme weather events, associated with the climatic variability phenomenon of the El Niño Southern Oscillation, are occurring with greater frequency and intensity in the region. This is worsening the state of food security and threatening all the other drivers of economic development. The following section highlights some of the findings based on climate change adaptation research in the agricultural sector in the sub-Saharan region with a specific focus on the East African region.

4.1 Vulnerability and adaptation of crop farming systems in the region

Changes in rainfall amounts and seasonal patterns are already being experienced in many parts of the world, including the East Africa region, creating problems for vulnerable farmers and other land users in securing their livelihoods, and increasing the risks they face. The frequency and intensity of extreme climatic events such as heat waves and erratic heavy rainfall, as well as the long-term chronic effects of higher temperatures, are set to increase (IPCC 2012).

In East Africa, the link between climate and agriculture as the main livelihood activity is very strong. As East Africa depends heavily on rain-fed agriculture, rural livelihoods are highly vulnerable to climate variability such as shifts in growing season conditions. Furthermore, agriculture contributes 40 percent of the region's GDP and provides a living for 80 percent of East Africans (Seitz and Nyangena 2009). In 2003–2004, all East African countries suffered from weather-related food emergencies, and can therefore be considered vulnerable to the impacts of climate change on their agriculture.

The various studies conducted in the East African Region indicate that smallholder farmers have observed changes in the amount and distribution of precipitation, associated with increases in temperature (Komba and Muchapondwa 2012). Farmers' responses have generally been using short season and drought-resistant crops, employing irrigation, adjusting planting dates and planting trees to adapt to the potential negative impacts of climate change on their agricultural yields (Ibid).

Some specific studies and analysis on potential impacts of climate change on crops in East Africa are available. It is reported for Tanzania that in the same farming system, positive and negative impacts may occur on different crops. It is suggested that impacts on maize, the main food crop, will be strongly negative for the Tanzanian smallholder, while impacts on coffee and cotton, significant cash crops, may be positive (Agrawala et al. 2003). In Kenya, a 1m sea level rise would cause losses of almost US$500m for three crops (mango, cashew nut and coconut) (Government of Kenya 2002). In the tea-producing regions of Kenya, a small temperature increase of 1.2°C and the resulting changes in precipitation, soil moisture and water irrigation could cause large areas of land that now support tea cultivation to be largely unusable. As Kenya is the world's second largest exporter of tea, and as tea exports account for roughly 25 percent of Kenya's export earnings and employ about three million Kenyans (ten percent of its population), the economic impact could be tremendous (WWF 2006, Simms 2005). The Ugandan NAPA demonstrates the dramatic impact that a 2°C temperature rise might have on coffee growing areas

in Uganda. The analysis indicates that most areas could become unsuitable for coffee growing (Government of Uganda 2007).

According to a study on the economics of climate change in East Africa, major rainfall deficient years and the major macro variables show a significant relationship between rainfall amount and GDP (Seitz and Nyangena 2009). Focusing on major drought years, a negative rainfall anomaly, especially one of more than ten percent, brings a loss in agricultural GDP. When the 1999–2000 drought affected an estimated 13.2m people, destroyed crops, caused deaths of animals and affected millions of people, the rainfall anomaly was about 29 percent based on the annual average figures, though the rainfall distribution was not uniform. The crop production loss was recorded at 16.8 percent. In the two consecutive years of 1999 and 2000, agricultural GDP in the EAC declined by 11 percent and 14 percent, leading to a GDP growth rate of -5 percent and -5.8 percent. An increase in temperature significantly lowers value of output for Kenya, Uganda and Rwanda.

Based on the study of economics of climate change in Kenya, it is reported that adaptation can reduce the economic costs of climate change but it too has a cost (SEI 2009). The costs of adaptation are still emerging. A number of categories of adaptation have been identified that relate to the balance between development and climate change. An initial estimate of immediate needs for addressing current climate impacts as well as preparing for future climate change for Kenya is US$500m/year (for 2012). The cost of adaptation by 2030 will increase: an upper estimate of the cost is likely to be in the range of $1-2bn/year. The study has also prioritised early adaptation across the sectors. These studies demonstrate that adaptation has potentially very large benefits in reducing present and future damages. However, while adaptation reduces damages, it does not remove them entirely.

Research on adaptation to climate change in the agricultural sector indicates that choices for adaptation depend on the available options in specific agro-ecological zones. Furthermore, the government can play a significant role by promoting adaptation methods appropriate for particular circumstances, crops and agro-ecological zones. According to FAO (2011), CA provides many benefits, including to the environment, such as addressing land degradation. CA helps foster agro-biodiversity and other essential environmental services, which improve agro-ecosystem resilience, helping farmers to better face risks and uncertainties. The productivity and diversity of crops also increase incomes and improve rural livelihoods. CA practices such as using leguminous crops, crop residues, cover crops and agro-forestry enhance soil fertility and lead to the stabilisation of soil organic matter and in many cases to a heightened sequestration of carbon in the soils.

CA assists farmers in adapting to climate change by establishing conditions that increase agro-ecosystem resilience to stress. Increasing an agro-ecosystem's adaptive capacity allows it to better withstand climate variability, including erratic rainfall and temperature variations and other unexpected events. Drawing on strong local community and farmers' knowledge and agro-biodiversity, ecological agriculture improves soil quality by enhancing soil structure and its organic matter content, which in turn promotes efficient water use and retains soil moisture. Such conditions simultaneously enhance soil conservation and soil fertility, leading to increased crop yields (FAO 2011). CA is claimed to be a panacea for the problems of poor agricultural productivity and soil degradation in SSA, reported to increase yield, reduce labour requirements, improve soil fertility and reduce soil erosion. It is thus being actively promoted by international research and development organisations. Some studies, however, raise concerns regarding the practicality of CA, which contributes to its low uptake in most SSA countries (Giller et al. 2009). The concerns include decreased yield, increased labour requirement and an important shift of the labour burden to women. This calls for critical assessment regarding under which ecological and socio-economic conditions CA is best suited for smallholder farmers in the region.

According to Chakeredza et al. (2009), a number of organisations worldwide, for example the United Nations Food and Agriculture Organization (FAO), are promoting the use of indigenous and locally adapted plants and animals as well as the selection and multiplication of crop varieties adapted or resistant to adverse conditions. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperatures, drought, floods, and high salt content in soil) allows harnessing genetic variability in new crop varieties. National programmes should have capacity built and long-term support to use these options. The study concludes that agro-forestry can enhance adaptation to climate change through provision of diversified tree products and services.

The predicted impacts of climate change must be introduced into development planning, including land-use planning, natural resources management, infrastructure design and measures to reduce vulnerability in disaster reduction strategies. The array of adaptation options is very large, ranging from purely technological measures to managerial adaptation and policy reform. For developing countries, availability of resources and adaptive capacity building are particularly important. Based on anticipated climate change and impacts on water resources in Africa, the Intergovernmental Panel on Climate Change (IPCC 2001) identified four necessary adaptive strategies.

a. **Adaptive measures.** Measures should be adopted that would enhance flexibility, resulting in net benefits in water resources (irrigation and water reuse, aquifer and groundwater management, desalinisation), agriculture (crop changes, technology, irrigation, husbandry) and forestry (regeneration of local species, energy-efficient cook stoves, sustainable community management).

b. **Risk sharing.** A risk-sharing approach between countries will strengthen adaptation strategies, including disaster management, risk communication, emergency evacuation and cooperative water resources management.

c. **Enhancement of adaptive capacity.** Local empowerment is essential in decision-making in order to incorporate climate adaptation within broader sustainable development strategies. Most countries in Africa are particularly vulnerable to climate change because of limited adaptive capacity as a result of widespread poverty, recurrent droughts, inequitable land distribution and dependence on rain-fed agriculture.

d. **Diversification.** To minimise sensitivity to climate change, African economies should be more diversified, and agricultural technology should optimise water usage through efficient irrigation and crop development.

All of the above adoptive strategies need to have strong gender perspectives. These strategies must consider the physical, gender and socio-economic factors that create vulnerability. The reality of climate stresses combined with diverse socioeconomic and gender roles and uneven ownership of resources such as land make it necessary to re-examine the adoptive conditions based on realities on the ground. The diverse roles and responsibilities become very significant in adoption of climate change for different categories of people. Gender inequalities in access to resources, such as land and other productive assets including credit, extension services, information and technology, must be taken into account with the root causes of gender inequality in developing mitigation activities and adaptation efforts.

As explained above, despite the usefulness of climate smart initiatives in the East African countries, only very few initiatives are being realised. In Kenya for instance there are several ongoing initiatives through the World Agroforestry Centre (ICRAF), and a number of initiatives are being developed. By yielding a broad range of products, including fruits, fuel wood, timber and resins, agroforestry helps farmers to diversify their incomes, providing them with greater protection against market failures and climate fluctuations. The use of nitrogen-fixing trees and shrubs increases soil fertility and crop yields. Trees also help farmers adapt to climate change, as perennial crops are better able to cope with droughts and floods than annual crops. Trees sequester much greater quantities of carbon than annual crops, and in some instances provide farmers with access to the carbon market. Atel (2012) reports that depending on how it is designed; agricultural carbon finance presents an opportunity for climate justice for smallholder farmers who are most vulnerable to climate change, while addressing the mitigation challenge. The triple win of higher yields, climate-resilient farming and carbon sequestration is theoretically possible. However, these wins are subject to complex socio-economic, political and cultural conditions that have strong bearing on their achievements, as the KACP case of Kenya highlights. However, Atel (Ibid) argues that the basic principles of agricultural carbon finance are new not only to many farmers but also to many researchers and government technocrats. In any case, farmers have a right to informed engagement in such mitigation and adaptation programmes. Exclusion, marginalisation and dependency may result from uninformed engagement and create new vulnerabilities. Capacity building about agricultural carbon finance for national policymakers and farmers is critical.

Regarding the whole aspect of carbon trading in Africa, the argument that carbon trading offers real benefits to the poor in Africa is simply not credible (Reddy 2011). It is found that if anything, offset schemes allow industrialised countries to maintain their affluent lifestyles by exporting the burden of reducing greenhouse gas emissions to countries in the South. Reddy (Ibid) further argues that fundamentally, inequality is behind the climate problem, and the search for solutions must involve industrialised societies making fundamental structural changes to their lifestyles, energy practices, and their production and consumption systems.

4.2 Vulnerability and adaptation of livestock in the region

Livestock are an integral part of the agricultural systems of Africa and especially important to the poor, who derive a larger proportion of their meagre incomes from livestock than do the wealthier (Delgado et al. 1999). In SSA the total output of animal products is worth most in the pastoral rangeland-based systems in the arid/semi-arid region, followed by the mixed rain-fed crop-livestock systems in the humid/sub-humid tropics, and then the mixed rain-fed crop-livestock systems in the arid/semi-arid tropics (ILRI 2000).

A study by Seo and Mendelsohn (2006a and 2006b, cited in IPCC 2007) also indicates that higher temperatures are beneficial for small farms that keep goats and sheep because it is easy to substitute animals that are heat-tolerant. Large farms, however, are more dependent on species such as cattle, which are not heat-tolerant. Increased precipitation is likely to be harmful to grazing animals because it implies a shift from grassland to forests and an increase in harmful disease vectors, and also a shift from livestock to crops (IPCC 2007). However, further increases in temperature would lead to gradual fall in net revenue per animal. Accordingly, it is reported that a warming of 2.5°C would be likely to decrease the income

of large livestock farms by 22 percent (US$13bn), whereas a warming of 5°C would probably reduce income by as much as 35 percent (US$20bn), resulting both from a decline in the number of stock and a reduction in the net revenue per animal.

4.3 Vulnerability and adaptation of pastoralist systems in the region

Climate change and variability are long-term environmental issues and pose serious threats to vulnerable and impoverished people worldwide through their direct impacts on the livelihoods systems, particularly those dependent on agricultural production (encompassing both crop and livestock production). In this context, governments, the scientific community, development organisations and the private sector increasingly recognise that drylands, grasslands and rangelands deserve greater attention, not only for their large extent, widespread degradation and limited resilience to drought and desertification, but also for their potential capacity to sequester and store carbon in soils while supporting sustainable pastoral and agro-pastoral livelihoods for millions of people (FAO 2009).

An estimated 50m pastoralists live in SSA (Rass 2006). Extensive mobile livestock production systems in sub-Saharan arid and semi-arid zones are important drivers in national economies as fundamental and ecologically sustainable food providers (Wiese 2004). However, these mobile pastoralists are politically and economically marginalised and must be fostered. Social and health planning relies on accurate data for fertility, mortality and causes of death (Setel et al. 2007). Countries in the Sahelian region of Africa face considerable challenges in sampling and registering mobile pastoralists. No demographic surveillance system includes data from these mobile communities, and few other approaches account for these people either.

Pastoralism is a subsistence system for producing meat, milk and other animal products from domesticated animals such as goats, sheep, cattle and camels. It is practiced in marginal areas where crop production is extremely difficult. Agro-pastoralism is a set of practices that combine pastoral livelihoods with production of millet, sorghum, maize, vegetables and legumes. These systems are extremely important and are the most prevalent land use in arid and semi-arid environments. Sixty-five percent of global drylands consist of grassland used for livestock production, contributing to the livelihoods of 800m people (Mortimore 2009).

Given the challenging environments where pastoralism and agro-pastoralism are practiced, they are highly vulnerable to climate shocks. Rising average temperatures and drought are major climatic risks affecting livestock-based livelihoods. As global and regional average temperatures increase, more of the already-sparse rainfall evaporates before hitting the ground. During periods of prolonged drought, agro-pastoral systems are put under stress and the people and livestock that depend on these systems experience increased vulnerability including reduced levels of food security. Increased frequency of extreme weather events including floods and droughts may overwhelm the existing resilience of pastoral systems.

The value of pastoralism has often been undermined. Studies have shown that desertification often occurs where policies undermine the pastoralist system, while where pastoralism has been supported by appropriate policies, biodiversity and ecosystem integrity have usually been enhanced (Hatfield and Davies 2006). Many pastoral systems are based on transhumant livestock production. Such systems are dependent upon the maintenance of access to land and water resources. When access to land is blocked, or use rights are uncertain, over-use and degradation often occur. Most pastoral lands have traditionally been communal with local institutional structures and governance preventing a 'tragedy of the commons'. These structures can take a number of forms. In some systems communal ranches have been established in which a number of families are granted ownership over a single large plot of land. In other cases high value land (such as water sources) are managed communally within a landscape of individual land titles for lower value land (CBD 2010).

Such systems are not always successful and must be developed in close consultation with stakeholders in order to avoid conflict and ensure the suitability of the land tenure arrangements. In other systems land or use rights are granted to a traditional governing body, which administers the land on behalf of the community. Each of these systems has advantages and disadvantages, which should be weighed based on local conditions and traditional management structures (CBD 2010).

Pastoralists play an important role in the flow of ecosystem goods and services in drylands. Pastoralists depend on the provision of fodder as livestock feed, as well as ecosystem services such as water cycling in these water-scarce regions. At the same time, their activities contribute to the production and stability of ecosystem services. Livestock grazing, for example, influences the fertility, distribution and diversity of plants, as animals scarify seeds in their guts, transport them over large distances, and fertilise grounds where seeds are deposited. The vegetation maintained through grazing activities in turn captures carbon, reduces erosion, maintains soils, facilitates water-holding capacity and provides habitat for wildlife (CBD 2010).

Detailed research on livestock vulnerability in East Africa is lacking, and impact assessments should be carried out. An example of the impact of climate change on livestock in East Africa is given in the NAPA of Uganda (Government of Uganda 2007). The subdivision of the Ugandan climate is reflected in the distribution of natural resources such as water, forest and vegetation. The so-called Cattle Corridor lies in the semi-arid climate and is predominantly a pastoral area, although the

rainfall is sufficient to support the growing of food for consumption in the area and neighbouring regions. The prolonged and severe drought of 1999/2000 and the resulting water shortage led to loss of animals, low production of milk, food insecurity, increased food prices and generally negative effects on the economy.

The traditional management systems in the drylands of East Africa must be responsive to variability and uncertainty. Pastoralists' knowledge of species, ecosystems and climate form the basis for sustainable land management. Management strategies include seasonal movement; use of tree leaves and pods during dry seasons; burning of old pastures; and feeding on crop residues. In many East African pastoral communities, selection of grazing sites is aided by scouts, who report on the condition of distant pastures, estimating how long the fodder and water will sustain a given number of livestock. In Sudan for example herds are not grazed at random, but in sites selected to be the best available, while sites in poorer condition are left to regenerate (Barrow et al. 2007).

Pastoralism in East Africa is typically based on local management systems for the sustainable use of wild and domesticated species. Grazing land management, especially in drought-prone areas, is a complex process requiring a balance between the use of water, food, fodder, fuel, etc. As users of grazing lands who are reliant upon the continued provision of such ecosystem services, pastoralists have a unique knowledge of how a balance between conservation and sustainable use can be achieved and maintained. In addition to seasonal and annual changes in use patterns, pastoralists are also able to quickly respond to perturbations. Because of their close historical connections with biodiversity, pastoralists also benefit from the cultural services provided by the ecosystems in which they live. This is often reflected in local management practices, which largely emphasise long time horizons in decision-making in order to maintain culturally important elements of the ecosystem. For example, in Rajasthan, India, Raika and Rabari pastoral people use local decision-making processes to sustainably manage mixed livestock herds to produce meat and milk (Blench 2000).

Many pastoral systems are steeped in traditional management and practices. Pastoralism is a livelihood system tied to ecosystem services with complex systems of social, political and economic organisation. Centralised decision-makers are often unaware of the challenges pastoral communities face in achieving and/or maintaining sustainable livelihoods, as there are few mechanisms for local communities to transmit their knowledge to outside decision-makers and the communities are often economically and politically marginalised. In fact, the erosion of indigenous and local knowledge, innovations and practices can reduce both the environmental and economic sustainability of pastoralism.

Raising livestock on drylands through seasonal migration is a uniquely efficient way to make use of lands that are unsuitable for other forms of agriculture (Neely et al. 2010). Rangeland resources are typically heterogeneous and dispersed, with their variation tied to seasonal patterns and variable climatic conditions. However, many researchers studying pastoral systems have concluded that extensive livestock production on communal land is the most appropriate use of semi-arid lands in Africa. Mobility and flexibility of pastoral systems enable them to make the best use of the patchy and fragile environment. However, pastoral communities remain among the most politically and economically marginalised groups in many societies. Many exist in persistent states of crisis resulting from drought, disease, raids, pastures and the fact that their transit routes are shrinking in the face of spreading cultivation, nature conservation and control of movements across international borders.

Climate change is causing increased competition between pastoralists and sedentary farmers, bringing with it a higher potential for localised conflicts. Faced with higher risks of crop failure linked to increased drought frequency, desertification and land degradation, a widespread response by farmers across the East African region is the diversification of income source to reduce reliance on a single activity. As such, sedentary crop farmers are increasingly developing livestock activities, raising competition for grazing lands with pastoralists and destabilising the traditional balance based on exchanges between the two groups. As a result, straying cattle are the main source of violent conflict between farmers and herders within the region.

The issue of cross-border conflict and pastoralists' access to key resources such as water and pasture in the region is a major security challenge in East Africa. The region has the world's largest grouping of pastoralists, with Sudan having the highest percentage. In Kenya, semi-arid and arid land constitutes 80 percent of the country's total land area, supporting 25 percent of the Kenyan population and half of its livestock (ACCES 2010). Central to these cross-border conflicts are pastoralists' desperate need to sustain their livelihood in the face of recurring droughts that are eroding their traditional coping capacities.

According to ACCES (2010), Eastern Africa has numerous pastoral groups in a broad geographical band stretching from the Kenya-Somalia border north into Ethiopia and northwest to encompass regions of Uganda, Sudan, the Democratic Republic of the Congo and the Central African Republic. The human security of pastoralist communities living along the borders is threatened due to increased cross-border armed conflict over resources. These regions have suffered large-scale intra-state wars that have supplied pastoralist groups with modern weaponry, resulting in protracted conflicts with numerous neighbours. Along with the availability

of small arms, depleted livestock, limited pasture and water, the cumulative effect of three years of drought are driving aggressive pastoralist cross-border movement in search of pasture and water in ways that are triggering violent cross-border conflict. Cattle-rustling incidents have increased in the region as owners seek to restock herds badly affected by the searing drought across local communities in East Africa. While drought is not uncommon to this region, a steady decline in rainfall has become the norm over the past two decades, a phenomenon that is likely related to the effects of climate change.

4.4 *Vulnerability and adaptation of fisheries in the region*

Marine and freshwater fisheries are susceptible to a wide range of climate change impacts. The ecological systems which support fisheries are already known to be sensitive to climate variability. For example, in 2007 the IPCC highlighted various risks to aquatic systems from climate change, including loss of coastal wetlands, coral bleaching and changes in the distribution and timing of fresh water flows, and acknowledged the uncertain effect of acidification of oceanic waters which is predicted to have profound impacts on marine ecosystems (Orr et al. 2005). Meanwhile, the human side of fisheries – fisher folk, fishing communities and related industries – are concentrated in coastal or low-lying zones which are increasingly at risk from sea level rise, extreme weather events and a wide range of human pressures (Nicholls et al. 2007). While poverty in fishing communities or other forms of marginalisation reduces their ability to adapt and respond to change, increasingly globalised fish markets are creating new vulnerabilities to market disruptions, which may result from climate change.

The vulnerability of an individual, community or larger social group depends on its capacity to respond to external stresses that may come from environmental variability or from change imposed by economic or social forces outside the local domain. Vulnerability is complex and depends on a combination of natural and socio-political attributes and geography. Non-climate factors such as poverty, gender-based exclusion, inequality, food insecurity, conflict, disease and globalisation can increase vulnerability by affecting the exposure, sensitivity and adaptive capacity of systems, communities and individuals (Adger et al. 2007). The vulnerability of fisheries and fishing communities depends on their exposure and sensitivity to change, but also on the ability of individuals or systems to anticipate and adapt. This adaptive capacity relies on various assets and can be constrained by culture or marginalisation. Vulnerability varies between countries and communities, and between demographic groups within society. Generally, poorer and less empowered countries and individuals are more vulnerable to climate impacts, and the vulnerability of fisheries is likely to be higher where they already suffer from over-exploitation or over-capacity.

Fisheries represent a significant source of revenue, employment and proteins for all East African countries. Climate change may have an impact on fisheries, as has been demonstrated for Lake Tanganyika by O'Reilly et al. (2003). They conclude that primary productivity in Lake Tanganyika may have decreased by as much as 20 percent over the past 200 years. Recent declines in fish abundance in East African Rift Valley lakes have also been linked to climatic impact on lake ecosystems.

As many tropical fish have critical thermal maxima beyond which they are unable to survive, climate change may also impact fisheries in East Africa (WWF 2006). Many tropical fish can indeed endure temperatures that are close to their temperature threshold. A 1-2°C increase, however, may exceed these limits, in particular for populations that currently exist in thermally marginal habitats (Roessig et al. 2004). However, because there is little data on the ability of these species to adjust their tolerance to water temperature, their response to climate change is largely unknown (WWF 2006).

Although the impact of climate change on fisheries is likely to be significant, it clearly needs to be assessed together with other human activities, including impacts that may arise from governance of fresh and marine waters (AMCEN/UNEP 2002). Furthermore, other factors depleting fish resources should be taken into account, such as pollution and overfishing.

Adaptation to climate impacts includes reactive or anticipatory actions by individuals or public institutions. These range from developing insurance and warning systems and changing fishing operations to abandoning fisheries altogether for alternative occupations. Governance of fisheries affects the range of adaptation options available and will need to be flexible enough to account for changes in stock distribution and abundance. Governance aimed towards equitable and sustainable fisheries, accepting inherent uncertainty and based on an ecosystem approach, as currently advocated, is thought to generally improve the adaptive capacity of fisheries. However, adaptation may be costly and limited in scope, so that mitigation of emissions to minimise climate change remain a key responsibility of governments (Daw et al. 2009).

Existing climate trends will increase over the next century (IPCC 2007) and are expected to impact more severely on aquatic ecosystems and, directly and indirectly, on fishing sectors, markets and communities. Loss of corals through bleaching is very likely to occur over the next 50 years, with consequent impacts on the productivity of reef fisheries and potentially on coastal protection as reefs degrade. Sea level will continue to rise and by 2100 will have increased by a further 20-60cm, leading to elevated extreme high sea levels, greater flooding risk and increased loss of coastal habitats. The traditional gender roles and gender-differentiated vulnerabilities of many populations is impacting men and women in different ways; therefore, these differences need to be captured with the root causes for better strategies for adoptions.

5 Agricultural policies for climate change adaptation

Although the East African countries have developed policies and established institutions/structures for environmental management and climate change issues, there are still a number of gaps pertaining to mainstreaming climate change matters in sectoral plans and programmes. Some key gaps were identified in the reviewed policies, macro strategies and sectoral strategies and plans.

Most African countries gained independence in the 1960s, a time when central planning was widely seen as a promising strategy for economic development (Anderson and Masters 2008). In this environment, elected governments across Africa typically kept the marketing boards and other instruments for intervention that had been developed by previous administrations, expanding their mandate and increasing public employment, in many cases as a means for electoral politics. In the 1970s, growing fiscal deficits, current account imbalances and overvalued exchange rates were supported by project aid and loans at a time of zero or negative real interest rates, as governments chose to ration credit and foreign exchange rather than expand the money supply. The result of growing government intervention was political instability and weak market institutions. It can be seen that during the first two to three decades, climate change issues were not key issues in the development agenda.

Most of the policies and strategies in the East African region, especially those produced prior to 2000 and before the production of NAPA, do not directly link to climate change matters. Even though they articulate matters that may contribute to climate change adaptation and mitigation, they have to be reviewed or implemented in the context of the changing climate, which has significant implications for sustainable natural resources management, sustainable development and community livelihoods. This is largely attributed to the fact that climate change is an evolving and cross-sectoral concern, which requires proactive, collective and gender response adaptation measures among interrelated sectors.

All the NAPA documents in the EAC have recognised the negative impacts of climate change on the main ecosystems in various ways depending on disaster. Accordingly, drought is the single most important and widespread disaster in Uganda, Tanzania, Burundi and Rwanda. According to the Government of Uganda (2007), drought is increasing in frequency and severity, particularly in the semi-arid Cattle Corridor. It impacts on a wide range of ecosystems, sectors and key social and economic programmes. Furthermore, storms, heavy rains and floods are the second most important cluster of disasters. This cluster of disasters negatively impacts on key sectors such as water resources, health, soils, wildlife and infrastructure. Loss of lives and physical injuries are associated with this cluster of disasters. The impacts of this cluster of disasters are most pronounced in the highland ecosystems.

Recently, Burundi worked out a Biological Biodiversity National Strategy and Plan of Action (SNPA-DB). Burundi also submitted its first National Communication to the UNFCCC. Regarding the Convention to Combat Desertification, Burundi further developed a National Plan of Action to Combat Desertification (PAN-LCD) (Government of Burudi 2007). In Rwanda, with a present weak adaptation capacity to the climate change due to a high level of poverty, drought, recurrent floods, strong dependence on rain-fed agriculture and a serious energy crisis hindering human development, building adaptation capacity necessitates the integration of adaptation measures to climate change in the global strategies of sustainable development (Government of Rwanda 2006). This principle is strongly applied in the choice of immediate and urgent adaptation measures identified in the framework of Rwanda's NAPA by the analysis of coherence and synergies with the sectoral policies and strategies of the country.

Apparently, climate change has not so far been adequately mainstreamed or integrated in sector-specific plans and strategies. Where efforts have been initiated, as in the water, agriculture and livestock sectors, there are still remaining implementation gaps. As such there is a need to develop climate change policy and legislation in the East African countries, which will promote establishment of an institutional framework for mainstreaming climate change matters in sectoral plans and programmes. Shayo (2006) notes that the completed Tanzanian NAPA was prepared in order to look at the country's climate change-related vulnerabilities in various sectors which are important for the economy. The completion of the NAPA in Tanzania will certainly enable the country to further integrate adaptation issues in the development process.

For most of the countries in the East African region, agriculture is the key to achieving broad-based, pro-poor economic growth and attaining the MDGs. Throughout history, increases in agricultural sector productivity have contributed greatly to economic growth and the reduction of poverty (OECD/FAO 2006). However, in the last decades, both governments and the donor community for various reasons have neglected the agricultural sector in Africa. From the 1980s onward, agriculture became increasingly ignored in many developing countries. This happened both in development cooperation policies – where the share for agriculture dropped from 18 percent in 1980 to four percent in 2007 – and in national budgets. The share of Official Development Assistance (ODA) to agriculture dropped significantly, falling from a peak of 17 percent in 1979, the height of the Green Revolution, to a low of 3.5 percent of total investment in 2004. It also declined in absolute terms: from US$8bn in 1984 to US$3.5bn in 2005 (World Bank 2008). While public investment in agriculture, particularly in smallholder agriculture and food security, from international donors and national governments declined sharply during the 1980s and

1990s, this period also witnessed strong growth in private sector agribusiness and the food industry, with structural shifts in research to private crop breeding and agrichemical development (de Janvry and Sadoulet 2010).

In assessing how much policy reform had taken place in Africa by the mid-1990s, how successful it had been, and how much more remained to be done, the World Bank (1994) concluded that progress had been made but reforms remained incomplete. The report also stressed that poor macroeconomic and sectoral policies were the main factors behind the poor performance of SSA's economy between the mid-1960s and the 1980s. Food markets were controlled by state enterprises, which also monopolised the import and distribution of fertilisers and other inputs, which were often supplied to farmers at subsidised prices and on credit. The prices farmers received were generally low because of taxation or high costs incurred by state enterprises. The negative impact of such policies on agricultural prices was particularly significant in the case of export crops. During this period, African governments followed a development strategy that prioritised industrialisation, with a clear bias against agriculture (Kherallah et al. 2000). Since the implementation of structural adjustment programmes promoted by international financial institutions in the 1980s and 1990s, policymakers and academics have argued about the causes of and solutions to the African crisis, as well as the impact of the structural adjustments (see, for example, Mkandawire 2005; Boratav 2001;).

Encouragingly, the New Partnership for Africa's Development (NEPAD), the economic programme of the African Union (AU), has recognised the importance of agriculture and wants to boost Africa's growth through agriculture-led development. This has led to establishment of two major initiatives, namely the Comprehensive Africa Agriculture Development Programme (CAADP) and African Peer Review Mechanism (APRM), NEPAD activities concerned with agricultural policies and institutions in SSA.

- CAADP is directed at agricultural sector policies including: (a) improving national agricultural policy frameworks; (b) strengthening institutions and governance; (c) enhancing agricultural productivity; (d) fostering trade, investment, economic growth and sustainable development; and (e) promoting regional integration.

- APRM aims at improving national governance and institutional settings in general. Given the prominence of agriculture in the economies of Africa, APRM may be expected to influence the agricultural sector as well.

It is important to highlight some common weaknesses of both APRM and CAADP, which strongly hamper their effectiveness to influence national agricultural policy processes and the policies themselves. According to Zimmermann et al. (2009), the key weaknesses are:

- Both initiatives, when implemented at the national level, were not well linked to ongoing, national policy processes but instead are stand-alone initiatives. Not enough care has been devoted to the docking of the processes onto and the channelling of the results into national processes. The implementation of the initiatives at the country level is planned without taking into account the existing policy cycles and windows of opportunities such as five-year plans, revisions of Poverty Reduction Strategy Paper (PRSP), or agricultural sector planning cycles. This, however, is crucially important since there can and should be only one relevant policy document per sub-sector. The incentives to adopt the results of the national exercises are not as high in cases like immediate additional donor support or government spending. Therefore, it is difficult to create new windows of opportunities. In most cases, this is not even desirable since reforms should not be bought but owned by convinced insiders. The initiatives do not sufficiently take into consideration the lengthy processes of agricultural policymaking, including parliamentary procedures that most democratic countries are committed to, particularly at the level of specific law formulation.

- Both APRM and CAADP tend to invite participation in an ad hoc manner. They both, and particularly CAADP, overestimate the capacity, especially of disadvantaged groups, to get involved in national policy processes. They do little to improve long-term and quality of participation in terms of participation capacity, networking, stabilisation of participatory structures, mandates of participants and so on. Rural populations are easily left out in a self organised process and disadvantaged in terms of representation by civil society organisations due to low media presence and population literacy, leading to an urban bias.

- Similarly, APRM and CAADP overestimate the flexibility and the mechanisms of donor support and probably also the lack of willingness to align. Despite the lip service paid to agricultural development, the agricultural sector is nominally funded in aid allocations, although the food price crisis may have changed that recently. However, for governance issues in general, lack of interest is certainly not the case. Governance is rated very high on donor agendas. The fact that even the political governance findings of APRM are not acknowledged and supported quickly and massively by donors indicates that the lack of embeddedness into national policies (see above) and the lack of flexibility

of donors may be important handicaps for such initiatives. Re-alignments are very slow, following the revision of key policies, and most often require lengthy adjustment processes such as bilateral negotiations and agreements. Donor representatives at the national level often do not have the mandate to react quickly.

- National and regional policy arenas are not yet well linked. The connections of agriculture, food security, and trade policies are not yet fully taken into account in setting the agenda for CAADP at the regional and national level. While much focus in the African regions is put on regional integration in general, the specific implications and regulatory consequences for agriculture are not yet fully recognised. The link is almost absent in APRM and theoretically strongly developed but in practice limited in CAADP. However, regional aspects of agricultural policymaking are predicted to increase in importance, if not due to CAADP and agricultural policy mandates for Regional Economic Communities (RECs), then due to regional trade policies, which heavily affect agricultural sectors of member countries. For the time being, however, regional links in African agricultural policies are not yet very strong.

The process to develop the East African Community Climate Change Policy (EACCCP) was initiated in response to a directive by the EAC Heads of State made during the 11th Summit of the Heads of State held in Arusha, Tanzania in 2009, to develop a regional climate change policy and strategies to urgently respond to the adverse impact of climate change, including addressing the challenge of food insecurity as a result of the extreme climatic conditions associated with climate change.

The aim of the Policy is to address the adverse impacts of climate change in the region, in response to the growing concern about the increasing threats of the negative impacts of climate change to national and regional development targets and goals. In addition, the development of the Policy is in fulfilment of the objectives of the EAC: to develop policies and programmes aimed at widening and deepening cooperation among partner states in accordance with the Treaty for the Establishment of the EAC. The Policy is consistent with the fundamental principles of the Treaty establishing EAC and principles of international environmental law according to the EAC Protocol on Environment and Natural Resources, the Protocol on Sustainable Development of Lake Victoria Basin and the UNFCCC. The preparation of the Policy was also guided by emerging issues and challenges faced by the region and potential benefits and opportunities in light of the increasing climate change.

The Policy was prepared in a consultative and participatory approach by experts drawn from the five EAC partner states (Burundi, Kenya, Rwanda, Tanzania and Uganda) and facilitated by the EAC Secretariat and the Lake Victoria Basin Commission Secretariat. The effective implementation of the prioritised climate change adaptation and mitigation measures identified by the Policy will depend on collaborative efforts by all relevant actors towards minimising the overall impacts of climate change and consequently lead to regional social and sustainable economic development.

6 Gaps in Climate Change adaptation research and policy in the agricultural sector

Discussion in the previous sections has shown that agriculture is one of the most widely studied sectors with respect to the impacts of climate change, as it is considered one of the most vulnerable sectors. Climate change and variability present new development challenges, particularly in SSA countries where the majority of the population depends on climate-sensitive activities, in particular agricultural production (FAO 2010; IFPRI 2010; Thompson et al. 2010).

It is further important to look through a gender lens and analyse the diverse situations of men and women across socioeconomic backgrounds when planning strategies. Each community has its own unique and dynamic situation. Gender roles and privileges vary from one location to another. Informed adaptation planning necessitates detailed gender analysis of each community. Sex-disaggregated data should be collected where possible to understand how men and women are being impacted differently and how adaptation strategies may affect them differently. Analyses should include effective participatory processes that are gender responsive.

During the past 20 years in Africa, a great deal of emphasis has been placed on the development of national agricultural research strategies and priorities, which have often occurred within the context of World Bank loans (IAC 2004). In addressing research issues that address climate change adaptation the following four African farming systems have been reported to offer the greatest potential for reducing malnutrition and improving agricultural productivity:

- The maize-mixed system, based primarily on maize, cotton, cattle, goats, poultry and off-farm work

- The cereal/root crop-mixed system, based primarily on maize, sorghum, millet, cassava, yams, legumes and cattle

- The irrigated system, based primarily on rice, cotton, vegetables, rain-fed crops, cattle, and poultry

- The tree crop-based system, based primarily on cocoa, coffee, oil palm, rubber, yams, maize and off-farm work

Literature review indicates that there is lack of detailed and systematic analysis of how climate change and variability affect the various agro-ecological zones of the East African Region. This implies that more research is needed to examine the existing farming systems to ascertain the effect of climate change in each of the respective agro-ecological zone. The review further shows that more research has been conducted in analysing the effects of climate change and variability on crop production. Apparently, little has been documented regarding the effect of climate change on the different livestock production systems in the East African region. The analysis of gender implications of climatic changes on agricultural sector also does not feature much in most of the articles reviewed. In considering how the impacts of climate change influence coping mechanisms, it is important to consider how both proactive and reactive adaptation mechanisms impact men and women differently. Without a gender-sensitive approach to adaptation planning, it is impossible to develop strategies that will meet the needs of both men and women and be effective in the long term.

CA appears to have potential in strengthening adaptation and resilience. However, empirical studies are needed in different agro-ecological zones to test its contribution to adaptation planning including mainstreaming climate change issues in the agricultural sector. CA is claimed to be a panacea for the problems of poor agricultural productivity and soil degradation in SSA. Yet according to some studies there are concerns regarding practicality of CA, which contributes to its low uptake in most SSA countries. Much of literature reviewed does not discuss much on the challenges associated with employment of such practices. This calls for rigorous research on the applicability of CA in enhancing resilience in the various agro-ecological zones of the EAC in the context of climate change.

Table 3: Assessment of stakeholders and their contribution to agricultural sector

Stakeholder	Contribution/Responsibility	Coverage
International Research Institutions		
International Maize and Wheat Improvement Centre (CIMMYT)	Creating, sharing and using knowledge and technology to increase food security, improve the productivity and profitability of farming systems and sustain natural resources.	Africa
International Water Management Institute (IWMI)	Improving the management of land and water resources for food, livelihoods and nature.	East Africa
International Development Research Centre (IDRC)	Researching on climate change adaptation in Africa with emphasis on Participatory Action Research	Africa
International Livestock Research Institute (ILRI)	Bringing high-quality science and capacity-building to bear on poverty reduction and sustainable development for poor livestock keepers and their communities.	Africa
National Research Institutes		
Mikocheni Agricultural Research Institute (MARI)	Conducting and promoting research for the development of the coconut sub-sector and tree crops-based farming systems along the coastal belt of Tanzania.	Tanzania
National Crops Resources Research Institute (NACRRI)	Generating and disseminating improved technologies of crops which include beans, cassava, cereals (maize and rice), sweet potato and animal production.	Uganda
National Agricultural Research Laboratories (NARLI)	Capacity for tissue culture, molecular biology and plant transformation.	Uganda
Plant Resources of Tropical Africa (PROTA)	Making scientific information about utility plants accessible in Africa and supporting their sustainable use to reduce poverty.	Tropical Africa
Regional Research NGOs		
Africa Harvest Biotech Foundation International (AHBFI)	Helping the poor in Africa achieve food security, economic wellbeing and sustainable rural development.	Kenya
International NGOS		
Famine Early Warning Systems Network (FEWSNET)	Providing timely and rigorous early warning and vulnerability information on emerging and evolving food security issues.	Uganda

Source: Kituyi (2008)

7 Analysis of stakeholders and opportunities for collaboration

The East African region is endowed with a good number and diversity of institutions that offer potential for collaboration and strengthening of the agricultural sector in the region (Kituyi 2009). These institutions range from research partnerships and networks to international research institutes, national research institutes, universities, regional research NGOs, universities, dual institutions, international NGOs, ministries, parastatals, intergovernmental organisations, private sector groups and civil society organisations. Table 3 presents some of the key institutions and their roles and responsibilities in supporting the agricultural sector in East Africa. It should be noted that some of these institutions operate beyond the EAC region.

8 Conclusions and recommendations

The concluding remarks outlined below are with respect to the key questions which this review was supposed to address.

1. *What is the role of climate change challenges in the context of the multiple challenges and opportunities facing the agriculture sector in the region?*

The adverse effects of climate change are already taking a toll on the livelihoods of communities in the East African region. The adverse impacts of climate change are a major challenge to socio-economic development globally. The African continent, including the East African region, is particularly vulnerable to impacts of climate change affecting key economic drivers such as water resources, agriculture and disaster risk management, among others. The impacts include water stress and scarcity; food insecurity; and high costs of disaster management as a result of increased frequency and intensity of droughts, floods and landslides associated with the El Niño phenomenon. However, it is important to analyse the impacts of climate change in the broader context, taking into consideration political, economic and social factors.

2. *What is the current state of knowledge on adaptation to climate change in the agricultural sector in the region?*

There is a considerable amount of research on climate change adaptation in the agricultural sector in East Africa. From the analysis of adaptation work, agricultural research appears to be a crucial area for adaptation to climate change in order to deal with changes in the length of growing seasons, increased droughts and periodic waterlogging as well as increased temperature and salinity in the area. National Agricultural Research Centres and the private sector in areas expecting more droughts in future should be supported to enable agricultural adaptation, taking on board climate smart agricultural practices.

CA appears to have potential in strengthening adaptation and resilience. However, empirical studies are needed at different agro-ecological zones to test its contribution to adaptation planning including mainstreaming climate change issues in the agricultural sector. CA is claimed to be a panacea for the problems of poor agricultural productivity and soil degradation in SSA. It is thus actively promoted by international research and development organisations. CA is reported to increase yield, reduce labour requirements, improve soil fertility and reduce soil erosion. Yet according to some studies there are concerns regarding the practicality of CA which contributes to its low uptake in most SSA countries. The concerns include decreased yield, increased labour requirement and an important shift of the labour burden to women. This calls for critical assessment regarding under which ecological and socio-economic conditions CA is best suited for smallholder farmers in the region. Empirical studies need to be conducted in different agro-ecological zones to test its contribution to adaptation planning. The donor community is called upon to provide the resources required for ecological agriculture interventions to meaningfully support food security and rural livelihoods. This entails ensuring that adequate and balanced financial allocations are made for ecological agriculture projects.

3. *What is the current state of knowledge on whether and how research findings are integrated in agriculture sector policies in the region?*

Despite a considerable number of climate change adaptation research projects in the East African region, there is little evidence regarding how the generated knowledge is made useful or integrated in the agricultural development plans of the respective countries. Integration and mainstreaming of climatic issues in agricultural sector represent one way. The link between agricultural research in the context of climate change and policymaking processes needs to be strengthened. This implies that the review of the various agricultural policies and initiatives within the East African region is based on knowledge generated to enhance adaptation. This can be achieved through proper packaging of research findings in a user-friendly way and sharing those findings through research-policy dialogues.

Effective adaptation decision-making needs to be informed by past, present and future climate information, enabling plans and actions for climate-resilient livelihoods and disaster risk reduction. Multi-stakeholder platforms of the agricultural sector and related sectors like AfricaInteract are required to enable sharing, understanding, interpreting and communicating of climate information, by giving space for dialogue on local adaptation issues and options.

4. *What are the major gaps in research on adaptation to climate change in the agricultural sector?*

Analysis of knowledge generated from adaptation research on the agricultural sector shows that little has been done to ensure that climate resilient approaches are integrated into the sector. This includes the use of climate smart agriculture. More research is also needed to show the inter-linkages of the agricultural sector and other related sectors such as water and energy. Integrated approaches are needed in development interventions aimed at promoting adaptation to climate change. Smallholders are exposed to global environmental change and economic globalisation, leading to competition between smallholder produce and highly subsidised produce from industrialised countries.

Combining local and scientific knowledge systems is important for making climate information relevant locally and for empowering communities, and is further necessary to enhance adaptation in the agricultural sector. Local adaptive capacity is enhanced by including communication and use of climate information in adaptation planning processes, enabling communities to live with the uncertainty and risks that climate change presents.

There is a need to understand the current status of climate change and gender research in the region. Addressing gender issues effectively in agricultural research is critical. Despite the recognised importance of gender analysis to the success of research and development initiatives, there are still limited voices of people for effective planning, implementation and monitoring frameworks and capacity development in gender analysis.

5. *What is needed to ensure that research findings are better integrated into agriculture sector policies?*

There is need to ensure that findings from agricultural research for climate change adaptation are well packaged and made user-friendly to various categories of stakeholders. There is also need for a mechanism to link stakeholders at the grassroots and other levels, vertically and horizontally. Despite the ongoing initiatives so far, the region lacks strong policies that can provide for implementation of necessary climate change adaptation strategies so far researched.

Some of the existing policies and frameworks such as the EACCCP are not yet felt at the grassroots. The aim is to develop a regional climate change policy and strategies to urgently respond to the adverse impact of climate change that includes addressing the challenge of food insecurity as a result of the extreme climatic conditions associated with climate change, including deepening cooperation among EAC partner states. Despite this strong framework so far in place, the implementation process is lacking in participation of grassroots communities. Furthermore, the agricultural and other sector policies in East Africa do not adequately provide for climate adaptation strategies, which has been a major weakness towards strengthening climate change adaptation in the region. Hence there is a need for an integrated, harmonised and multi-sectoral framework for responding to climate change in the EAC region through the EACCCP. The need to build capacity in gender analysis for generation of gender-disaggregated data and its better analysis and interpretation for realistic policy statements is a prerequisite.

6. *What is the current state of knowledge on the stakeholders involved with research and policy on adaptation to climate change in the agricultural sector in the region, and how could stakeholder involvement be improved?*

The analysis of review findings has shown that there are various actors who are involved in climate change adaptation within the agricultural sector in the East African region. The only challenge is to see how these stakeholders can be well coordinated to strengthen adaptation of agricultural communities in the region.

African smallholder farmers have no alternative but to adapt to climate change and climate variability. This will require an unprecedented level of political commitment, increased investments and financial resources, and enhanced local and national capacity. Fortunately, several practical options for adaptation exist, and these must be refined, augmented and deployed appropriately as a matter of urgency.

Gender-disaggregated data should be collected where possible to understand how men and women are being impacted differently and how certain adaptation strategies may affect them differently. Gender analyses should include effective participatory processes that are designed to collect such data and highlight the needs of all community members. Coping strategies that are beneficial for both men and women, have positive environmental impacts and are sustainable should be formally recorded, supported and popularised amongst other communities.

End Notes

[1] The review included the countries of Tanzania, Kenya, Uganda, Burundi, Rwanda and Ethiopia.

[2] Conservation agriculture is outlined as a series of principles and practices that include application of modern agricultural technologies to improve production while concurrently protecting and enhancing land resources on which production depends (Dumanski et al. 2006). It includes technologies such as zero tillage and agro-forestry

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Future Agricultures

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