

Acknowledgement

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

Research and Policies for Climate Change Adaptation in East Africa Agriculture SUMMARY



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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

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1. Introduction

African countries continue to be highly vulnerable to climate change, making the continent the region in the world most exposed to the impacts of climate change (World Bank 2008). Vulnerability is aggravated by widespread chronic 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). The impacts of climate change result in high risks to national food and water security, livelihoods, shelter and health.

Agriculture remains a key factor in East Africa, for spurring growth and lifting large numbers of people out of poverty. Rain-fed farming dominates the farming system in East Africa, and only a small area is irrigated (Rosegrant et al. 2002). Climate models for the East African region show that rainfall regimes will change but these changes will vary with season and region. Research on adaptation to climate change in the East Africa 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 involved using short season and drought-resistant crops, employing irrigation, adjusting planting dates and planting trees to manage the potential negative impacts of climate change on agricultural yields.

The United Nations Framework Convention on Climate Change (UNFCCC) has provided support to the Least Developed Countries (LDCs) in Africa to undertake National Adaptation Programmes of Action (NAPAs). NAPA documents for Tanzania, Uganda, Rwanda and Burundi highlight priority areas in support of climate change adaptation. These priority areas include (i) improving food security in drought prone areas through improved water availability and cropping of drought tolerant crops, (ii) integrated water resource management, (iii) seasonal early warning, (iv) land use planning, (v) intensive livestock grazing, (vi) emphasis on indigenous knowledge (IK) and (vii) supporting non-agricultural income generating activities.

There is growing interest in support for research on climate change adaptation strategies in Africa, and findings emerging from relevant research inform policy formulation and decision making for climate change adaptation. It is critical that agriculture sector policies are appropriately informed by the existing body of knowledge, generated from scientific research, on climate change and climate variability.

This report is a summary of an extensive literature review which identified gaps in research and national policies for climate change adaptation in East Africa agriculture. The review commissioned by the IDRC funded AfricaInteract project focused on analysis of the agricultural sector in the context of climate change in East African countries, particularly Kenya, Tanzania, Uganda, Burundi, Rwanda and Ethiopia. In conducting this review, answers were sought to the following questions:

1. What is the current state of knowledge on adaptation to climate change in the agricultural sector in the region?
2. What is the current state of knowledge on whether and how research findings are integrated in agriculture sector policies in the region?
3. What are the major gaps in research on adaptation to climate change in the agricultural sector?
4. What is needed to ensure that research findings are better integrated into agriculture sector policies?
5. 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 review provides information and insights into mechanisms to promote linkages and collaboration between researchers and policymakers to improve evidence-based policy formulation to enhance food security and protect sections of the populations that are most vulnerable to climate change.

Definitions of Key Concepts

Coping and 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).

Adaptation (Adger et al. (2007) defined 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'.

Vulnerability- 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).

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

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 after some process, or products that can be feed to other livestock/organisms that can be consumed directly at maturity. 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.

2. Overview of the East Africa Agriculture Sector

Agriculture remains a key factor in East Africa, for spurring growth and lifting large numbers of people out of poverty. Agriculture is a principal route to meeting the Millennium Development Goals (MDGs) (Zimmermann et al. 2009) and is a key for achieving national food security, and for survival; a means of livelihood and culture; and a provider of environmental services for various categories of population. The status of agriculture and economic contributions of the agricultural sector in East Africa are illustrated in Figure 1.

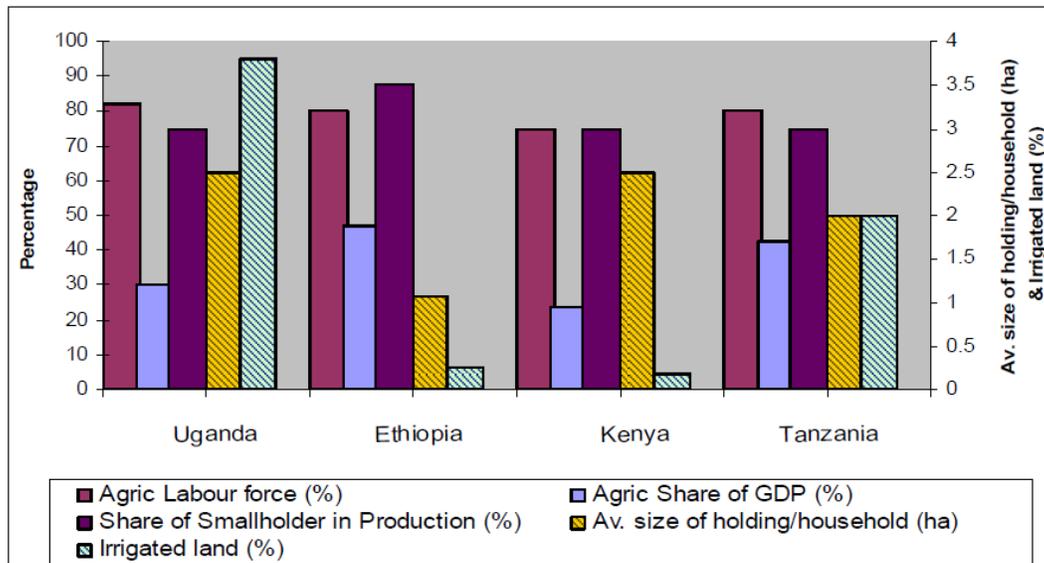


Figure 1: Status of agriculture and economic contribution in East Africa

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

Rain-fed farming dominates the farming system in East Africa, and only a small area is irrigated (Rosegrant et al. 2002). Agricultural production systems in the region 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 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. Leguminous crops cultivated include beans and cowpeas. The region also hosts a diversity of livestock production systems, covering pastoral, agro-pastoral and mixed rain-fed types ranging from the semi-arid to sub-humid tropical highlands

East African farming systems are characterised by weathered soils of low inherent fertility and high fragility; declining soil fertility due to population growth and minimal use of external inputs. Rainfall is highly variable, especially in the drier rain-fed systems. For the foreseeable future, multiple farming systems, in the context of climate change, will become more productive to generate the increases in food required to feed the hungry in the East African region.

Africa is experiencing a general warming trend, with certain regions warming more than others (Boko et al. 2007). Climate models for the East African region show that rainfall regimes will change but these changes will vary with season and region. Warming is estimated at approximately 0.5°C per century since 1900 (Hulme et al. 2001). Temperature projections for East Africa indicate that the median near-surface temperature during the 2080–2099 periods will increase by 3–4°C compared to the 1980–1999 period. 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. According to 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.

3. Research on Climate Change Adaptation in East Africa Agriculture

The adverse impacts of climate change and variability are aggravated by rising average global temperatures and seriously threaten 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, worsening the state of food security and threatening all the other drivers of economic development. Research on climate change adaptation conducted in East Africa has yielded interesting findings which address these issues.

Research results on adaptation to climate change in the East Africa 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 involved using short season and drought-resistant crops, employing irrigation, adjusting planting dates and planting trees to manage the potential negative impacts of climate change on agricultural yields. 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).

Studies on potential impacts of climate change on crops in East Africa show that in Tanzania, positive and negative impacts may occur on different crops in the same small holder farming system. Impacts on maize will be strongly negative, 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 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.

Results of research on the economics of climate change in East Africa reveal that 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 10 percent, results in a loss in agricultural GDP.

Studies on the economics of climate change in Kenya reported that adaptation can reduce the economic costs of climate change at a cost (SEI 2009). Categories of adaptation have been identified that relate to the balance between development and climate change. An initial estimate for the year 2012, of immediate needs of US\$500m is estimated in Kenya for addressing current climate impacts as well as

preparing for future climate change. In 2030, this cost is estimated to increase to an upper limit in the range of \$1-2bn/year. The study has also prioritized early adaptation across the sectors and demonstrated that adaptation has potentially huge benefits in reducing future damages.

Research conducted on adaptation to climate change in the agricultural sector indicates that choices for adaptation depend on the available options in specific agro-ecological zones, for example, through the promotion and adoption of Conservation Agriculture (CA). According to FAO (2011), adoption of CA benefits the environment, including addressing land degradation, fostering agro-biodiversity, and enhancing soil fertility, which improve agro-ecosystem resilience, and help farmers to better manage risks and uncertainties. The productivity and diversity of crops cultivated under CA increase incomes and improve rural livelihoods. CA assists farmers in adapting to climate change through establishing conditions that increase agro-ecosystem resilience to stress (FAO 2011).

Furthermore, research has shown that climate adaptation can be achieved through 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.

The World Agroforestry Centre (ICRAF) is promoting a number of initiatives related to climate change adaptation. 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.

Livestock - Livestock are an integral part of the agricultural systems of East Africa and especially important to the poor, who derive a large proportion of their incomes from sale of livestock. (Delgado et al. 1999). A study by Seo and Mendelsohn (2006a and 2006b, indicated that higher temperatures are beneficial in 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. 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. 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 a shift from livestock to crops (IPCC 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. 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. Research on livestock vulnerability in East Africa is lacking, and impact assessments should be carried out.

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.

Fisheries - Marine and freshwater fisheries are susceptible to a wide range of climate change impacts. The ecological systems which support fisheries are sensitive to climate variability. 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 as well as discussing the uncertain effect of acidification of oceanic waters which is predicted to have profound impacts on marine ecosystems (Orr et al. 2005). 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).

Fisheries represent a significant source of revenue, employment and proteins in 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). These researchers concluded 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 associated with climatic impact on lake ecosystems.

Although the impact of climate change on fisheries is likely to be significant, research needs to be conducted to assess, together with other human activities, impacts that may arise from governance of fresh and marine waters (AMCEN/UNEP 2002). Furthermore, other factors, to be studied include pollution of aquatic systems and depleting fish resources, as well as examination of mechanisms of how traditional gender roles and gender-differentiated vulnerabilities of many populations are impacting on men and women and the root causes in a bid to design better strategies for adaptation.

4. Sector Policies for Climate Change Adaptation in East Africa Agriculture

Although East African countries have developed policies and established institutions/structures for environmental management and climate change issues, mainstreaming climate change matters in sectoral plans and programmes remains incomplete. Most African countries gained independence in the 1960s, a time when central planning was widely regarded as a promising strategy for economic development (Anderson and Masters 2008). During this period, elected African governments typically retained a policy of marketing boards and other instruments for intervention that had been developed by previous administrations, expanding their mandate and increasing public employment.

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.

Thus during these three decades, climate change issues were not key issues in national development agendas.

Most of the policies and strategies of countries in the East African region, especially those developed prior to 2000 and before the production of NAPA, do not directly incorporate climate change issues. Although these policies and strategies articulate matters that may contribute to climate change adaptation and mitigation, they have to be revisited 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 because climate change is an evolving and cross-sectoral concern, which requires proactive, collective and gender response adaptation policies and measures among interrelated sectors. Climate change has not been adequately mainstreamed or integrated in sector-specific policies, plans and strategies in East Africa countries. Where efforts have been initiated, as in the water, agriculture and livestock sectors, implementation gaps remain. Therefore, it is necessary to develop climate change policy and legislation in the East African countries, in order to promote establishment of an institutional framework for mainstreaming climate change matters in sectoral plans and programmes.

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, development of the East African Community Climate Change

Policy (EACCCP) was initiated to produce a regional climate change policy and strategies to urgently address the adverse impact of climate change, including the challenge of food insecurity caused by 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 growing concern about the increasing threats of the negative impacts of climate change to national and regional development targets and goals. Furthermore, 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 the principles of international environmental law consistent with the EAC Protocol on Environment and Natural Resources, the Protocol on Sustainable Development of Lake Victoria Basin and the UNFCCC. Preparation of the Policy was also guided by emerging issues and challenges faced by the region and potential benefits and opportunities emerging from the increasing climate change.

The East African Community Climate Change Policy was prepared through 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. 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 leading to regional social and sustainable economic development.

5. Research Gaps in Climate Change Adaptation and Sector Policies in East Africa Agriculture

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). Gender roles and privileges vary from one location to another. Informed adaptation planning requires detailed gender analysis of each community. Sex-disaggregated data should be collected where possible to understand how men and women are impacted differently and how adaptation strategies may affect them directly. Analyses should include effective participatory processes that are gender responsive.

During the past 20 years in Africa, considerable development of national agricultural research strategies and priorities, has taken place with support from World Bank loans (IAC 2004). In planning research programmes that address climate change adaptation four African farming systems were incorporated to offer the greatest potential for reducing malnutrition and improving agricultural productivity. These farming systems are

- 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

Detailed and systematic analysis is lacking on how climate change and variability affect the agro-ecological zones of the East African Region. This implies that more research is needed to define the existing farming systems in order to determine the effect of climate change in each of the agro-ecological zones.

Some research has been conducted to analyse the effects of climate change and variability on crop production, but little has been documented regarding the effect of climate change on livestock production systems in the East African region.

Although conservation agriculture (CA) has the potential to strengthen capacity for climate change adaptation and resilience, empirical studies are needed in different agro-ecological zones to evaluate the contribution of CA to adaptation planning including mainstreaming climate change issues in the agricultural sector.

6. Stakeholders and Opportunities for Collaboration in Research on Climate Change in East Africa Agriculture

The East African region hosts a variety of stakeholder institutions that offer potential for collaboration in research on climate change and strengthening of the agricultural sector. (Kituyi 2009). These institutions include research partnerships and networks, international agricultural research institutes, national research institutes, universities, regional research centers, universities, dual institutions, NGOs, Government Ministries, parastatals, intergovernmental organizations, private sector groups and civil society organizations. Table 2 presents a list of the key institutions and their roles and responsibilities in supporting the research and collaboration on climate change in the East Africa agricultural sector.

Table 1: 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. Conclusion and Recommendations

The review of research and policies on climate change adaptation in East Africa has identified several issues that affect the capacity of East African countries to effectively address issues of climate change adaptation. 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. Climate change 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.

Agricultural research is a crucial area for developing mechanisms for adaptation to climate change in order to manage changes in the length of growing seasons, increased droughts and periodic water logging as well as increased temperature and salinity in East Africa agriculture. National Agricultural

Research Centers and the Private Sector, in areas expecting more droughts in future, should be supported to enable climate change adaptation, in the context of climate smart agricultural practices.

Conservation Agriculture (CA) offers potentials for strengthening climate change adaptation and resilience. However, empirical studies are needed at different agro-ecological zones to evaluate the contribution of CA to climate change adaptation planning including mainstreaming climate change issues in the agricultural sector. Adoption of CA practices is reported to increase crop yields, reduce labour requirements, improve soil fertility and reduce soil erosion. But according to some studies, there are some concerns regarding the practicality of CA which contributes to its low uptake in most SSA countries. Concerns include increased labour requirement and an important shift of the labour burden to women. This calls for critical assessment regarding the ecological and socio-economic conditions where CA is best suited for smallholder farmers in East Africa. Empirical studies need to be conducted in different agro-ecological zones to evaluate the contribution of CA to adaptation planning. The donor community is called upon to provide the resources required for ecological agriculture interventions which will adequately support food security and rural livelihoods. This involves ensuring that adequate and balanced financial allocations are allocated for ecological agriculture projects.

Despite the implementation of many climate change adaptation research projects in the East African region, there is limited evidence regarding how the information and knowledge generated from research is used or integrated and mainstreamed into national agricultural development policies, strategies and plans of the East African countries. The link between agricultural research in the context of climate change and policy formulation 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 from research to enhance climate change adaptation. This can be achieved through proper packaging of research findings in a user-friendly way and sharing research 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 relevant actors like AfricaInteract are required to enable sharing, understanding, interpreting and communicating of climate information, through providing the space for dialogue on local adaptation issues and options.

Analysis of knowledge generated from climate adaptation research in the agricultural sector, show that little has been done to ensure that climate resilient approaches are integrated into the sector. 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 to promote adaptation to climate change.

Combining indigenous 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. There is need to ensure that findings

from agricultural research for climate change adaptation are well packaged and made user-friendly for various categories of stakeholders. Rural stakeholders should be linked to other levels, vertically and horizontally. Although there are several ongoing initiatives on climate change adaptation in East Africa, the region still lacks strong policies that can provide for implementation of necessary climate change adaptation strategies. Some of the existing policies and frameworks such as the EACCCP are not yet felt at the grassroots. The aim of EACCCP 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 resulting from the impact of extreme climatic conditions associated with climate change, including deepening cooperation among EAC partner states. Although this strong framework has been endorsed, the implementation process is lacking participation of grassroots communities. Furthermore, the agricultural and other sector policies in East Africa do not adequately provide for climate change adaptation strategies, which has been a major weakness towards strengthening climate change adaptation in the region. Consequently, there is need for an integrated, harmonized and multi-sectoral framework for responding to climate change in the East Africa region through the EACCCP.

Addressing gender issues effectively in agricultural research is critical for climate change adaptation. Despite the importance of gender analysis to the success of research and development initiatives, there are limitations in effective planning, implementation and monitoring frameworks and capacity development in gender analysis. 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. Gender analyses should include effective participatory processes that are designed to collect such data and highlight the needs of all community members. Capacity should be strengthened in gender analysis and generation of gender-disaggregated data and interpretation for realistic policy formulation.

African smallholder farmers must adapt to climate change and climate variability. This will require high levels of political commitment, increased investments and allocation of adequate financial resources, and enhanced local and national capacity. Fortunately, several practical options for adaptation exist, and these must be urgently refined, augmented and deployed appropriately. Finally, this review has shown that there are various actors who are involved in climate change adaptation within the agricultural sector in the East African region. A major challenge is to establish a well-coordinated and functional platform for these stakeholders to strengthen adaptation of agricultural communities in the region.

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