# State of Knowledge on CSA in Africa: Case Studies from Ethiopia, Kenya and Uganda

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# State of Knowledge on CSA in Africa:

# Case Studies from Ethiopia, Kenya and Uganda

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## Foreword

The evidence of climate change such as rising temperature and changes in precipitation is undeniably frequent in recent years with impacts already affecting our ecosystems, biodiversity and people. One region of the world where the effects of climate change are being felt particularly hard is Africa. With limited economic development and institutional capacity, African countries are among the most vulnerable to the impacts of climate change. The long-term impact of climate change on food and nutritional security and environmental sustainability is continuously gaining attention, particularly in Sub-Saharan Africa.

Africa depends heavily on rain-fed agriculture making rural livelihoods and food security highly vulnerable to climate variability such as shifts in growing seasons. Existing technologies and current institutional structures seem inadequate to achieve the mitigation needed to adequately slow climate change effects, while also meeting needed food security, livelihood and sustainability goals. Africa needs to identify actions that are science-based, utilize knowledge systems in new ways, and provide resilience for food systems and ecosystem services in agricultural landscapes despite the future uncertainty of climate change and extreme events. It is imperative therefore that new modes of science-policy integration, transform land management and community action for food security as well as for conservation of biodiversity and the resource base upon which agriculture depends.

Climate Smart Agriculture (CSA) is one of the innovative approaches of sustainably increasing productivity of crops, livestock, fisheries and forestry production systems and improving livelihoods and income for rural people, while at the same time contributing to the mitigation of the effects of Climate Change. CSA combines the improvement of social resilience with the improvement of ecological resilience and promotes environment friendly intensification of farming systems, herding systems and the efficiency of sustainable gathering systems. The increase in production boosted through CSA should be driven through adequate combination of technologies, policies, financing mechanisms, risk management schemes and institutional development. It is imperative therefore, that CSA should be embedded into identified development pathways, transforming food systems, landscapes, farming systems and practices adapted to communities to bring “triple wins” that enhance opportunities to increase agricultural productivity, improve resilience to climate change, and contribute to long-term reductions in dangerous green house gas.

Although there are many research and analytical efforts to minimize the impact of climate change on agriculture and livelihoods in Africa by various actors, there is however, no coherent documented state of knowledge of CSA practices in Africa.

FARA is aware that there are ongoing successful CSA practices across Africa.

Identifying and documenting successful CSA practices has been a challenge. FARA with support from the Norwegian Agency for Development Cooperation (NORAD) undertook a series of studies in twelve countries to generate data and information on CSA issues that can be used to support evidence-based CSA policy and programme design, and performance monitoring. This report presents the state of CSA as it exists in Kenya, Ethiopia and Uganda.

It is expected that the knowledge and information contained within will support future efforts aimed at addressing climate change issues in the three countries.

Yemi Akinbamijo
Executive Director, FARA

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# Acronyms and Abbreviations

| | |
|---|---|
| AEZ | Agro-ecological Zone |
| ASAL | Arid, -Semi-Arid Land |
| ASARECA | Association for Strengthening Agricultural Research in Eastern and Central Africa |
| AU | African Union |
| CAADP | Comprehensive Africa Agriculture Development Programme |
| CCAFS | Climate Change, Agriculture and Food Security |
| CCARDESA | Centre for Coordination of Agricultural Research and Development for Southern Africa |
| CGIAR | Consultative Group on International Agricultural Research |
| COMESA | Common Market for Eastern and Southern Africa |
| CORAF | West and Central African Council for Agricultural Research and Development |
| CSA | Climate Smart Agriculture |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| EAC | East African Community |
| ENDA | Environment and Development of Developing Countries |
| EU | European Union |
| EVI | Economic Vulnerability Index |
| FAAP | Framework for African Agricultural Productivity |
| FANRPAN | Food, Agriculture and Natural Resources Policy Analysis Network |
| FAO | Food and Agriculture Organization of the United Nations |
| FARA | Forum for Agricultural Research in Africa |
| GCM | General Circulation Model |
| GEF | Global Environment Fund |
| GHG | Green House Gas |
| GTP | Growth and Transformation Plan |
| HAI | Human Asset Index |
| IFAD | International Fund for Agricultural Development |

| | |
|---|---|
| IITA | International Institute of Tropical Agriculture |
| IPCC | Intergovernmental Panel on Climate Change |
| KARI | Kenyan Agricultural Research Institute |
| KARLO | Kenyan Agricultural and Livestock Research Organization |
| NAFSIP | National Agriculture and Food Security Investment Plan |
| NAIP | National Agricultural Investment Plan |
| NAMA | Nationally Appropriate Mitigation Actions |
| NAP | National Adaptation Plan |
| NAPA | National Adaptation Programme of Action |
| NARS | National Agricultural Research Systems |
| NEPAD | New Partnership for Africa's Development |
| NERICA | New Rice for Africa |
| NCCAP | National Climate Change Action Plan |
| NCCIF | National Climate Change Implementation Framework |
| NCCRS | National Climate Change Response Strategy |
| NORAD | Norwegian Agency for Development Cooperation |
| PASDEP | Plan for Accelerated and Sustained Development to End Poverty |
| SADC | Southern African Development Community |
| SALM | Sustainable Agricultural Land Management |
| SDPRP | Sustainable Development and Poverty Reduction Program |
| SLM | Sustainable Land Management |
| SRO | Sub-Regional Organizations |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WECARD | West and Central African Council for Agricultural Research and Development |
| WFP | World Food Programme |

# Executive Summary


The adverse impacts of climate change and variability are a threat to the ecosystems and livelihoods of communities in Eastern Africa. Severe droughts, floods and extreme weather events are occurring with greater frequency and intensity in the region. Food production systems and technologies need to adapt to the emerging climatic scenarios in order to improve food security and contribute to the development of other sectors. The Climate Smart Agriculture (CSA) approach offers an opportunity for achieving triple-wins of food security, adaptation and mitigation. The Forum for Agricultural Research in Africa (FARA), recognizing the need to promote CSA in Africa and with support from the Norwegian Agency for Development (NORAD), carried out the state of knowledge on CSA in Ethiopia, Kenya and Uganda.

The primary purpose of the study was to identify and document the Best Practices of Climate Smart Agriculture that can be shared, scaled up and scaled out in order to mitigate the effects of climate change on food security and livelihoods. The three Eastern African countries of Kenya, Ethiopia and Uganda were the focus of the study. Specific objectives were to:

i) Identify, document and collect data and information on successful CSA practices for scaling up and scaling out
ii) Document and collect data and information on policies that promote CSA
iii) Identify existing gaps and investment opportunities where CSA can intervene within the Comprehensive Africa Agriculture Development Programme (CAADP) framework
iv) Determine the drivers, challenges or opportunities that may facilitate or hinder scaling up and scaling out CSA practices
v) Ascertain the priority crops and livestock that are suitable for CSA practices across different agro-ecological zones in the region

Data was obtained from desk-based studies and rapid field surveys with key informants who are experts in the field of climate change and CSA. Key messages include the following:

- Eastern Africa is experiencing climate change, which is manifested as an increase in the frequency and intensity of climatic hazards such as droughts, floods, and frosts. Predicted changes in climatic factors are variable, although there will generally be increased temperature, increased rainfall and rainfall variability. The impacts of climate change on agriculture are varied depending on the type of predictive models used, crop varieties and the agro-ecological zone.
- The adaptive capacity of African farmers is low as a consequence of poor socio-economic circumstances, harsh biophysical environments, inadequate technology, and poor infrastructure.
- The regional populations and governments are vulnerable to the effects of climate change. The Human Development Index and the Economic Vulnerability Index are unfavorable in the survey countries.
- As a holistic approach, CSA is not yet

apparent for government agencies and local farmers. Rather, elements of CSA are being implemented in a peacemeal fashion. Many of the technologies are designed with the primary purpose of increasing production instead of protecting the natural resource base. A CSA communication strategy needs to be developed.

- There are a range of appropriate technologies that have been recommended for the different agro-ecological zones of Eastern Africa. These technologies have the capacity to improve food production, enable farmers to maintain their food production with climatic changes, and contribute to mitigation through minimization of GHG emissions. The CSA approach provides an opportunity for agriculture to contribute to investments for increased production through participation in carbon markets.
- There are no specific policies promoting CSA at national, sub-regional, and regional levels. The National Food Security and Investment Plans have elements of CSA but do not explicitly promote it. The study did not identify any confirmed successful national policy models for inter-sectoral collaboration and leveraging of finance, although policy and strategy documents mention inter-ministerial committees and decentralization of government functions to district level.
- There are significant gaps in capacity, technical knowledge and financing for addressing impacts of climate change on agriculture. There are few models that deal with livestock and none that deal with heat or water stress effects. In addition, the integration of adaptation and mitigation into policy and practice, and mainstreaming of climate change issues into agricultural development are lacking. There are financial gaps because governments are unable to fund their National Agriculture and Food Security Investment Plans (NAFSIPs).
- The drivers for scaling up CSA include approaches to technology dissemination; communication and information; capacity building in CSA; social capital; appropriateness and profitability of CSA technologies; access to credit, inputs and markets; gender equity; strong government support, both for policy and scaling up frameworks; overall national economic environment; finances from multiple sources; and incentives for farmers.
- Technologies need to be evaluated to assess suitability to small-holder farming circumstances and characteristics (socio-economic conditions) and assess effects on long-term farm productivity, efficiency in resource use and improvement of production factors.
- The following practices need to be up-scaled and out-scaled: improved drought tolerant crop varieties and livestock breeds (mainly adaptation measures); Integrated soil fertility management (including micro-dosing), Water harvesting (including zai pits), Cross slope barriers (stone bunds/ vegetative barriers), Agroforestry (including parklands and assisted natural regeneration) and Lowland rice cropping. In areas where rainfall is predicted to decline, drought tolerant crop species and varieties should replace less drought tolerant ones and vice versa in areas where rainfall may

rather increase. It is also recommended that varieties with tolerance to salinity, flooding and drought, are developed and are responsive to integrated soil fertility management.

- In addition to technological options, climate risk management techniques such as seasonal weather forecasting, index-based insurance and safety nets should be promoted. The community-based participatory climate smart village approach involving climate risk management should also be encouraged.

Governments play a critical role in promoting CSA through financing and policy incentives. Coordination can lobby governments for buy-in as a major step towards widespread promotion of CSA in the region. Addressing the socio-economic and structural constraints facing farmers provides opportunities to promote CSA in eastern Africa. The key is to ensure the effective flow of targeted information on CSA communication platforms through highly skilled extension staff. Investments are also required to develop CSA communities of practice and regional carbon markets.

# 1. Introduction

## 1.1 Background

The negative impacts of climate change are already evident in the East African region. Climate variability and change has been documented and demonstrated in a number of ways, including rising temperature, changes in precipitation patterns and quantity, and incidence of storms and frosts (Gok, 2010; Maitima, et al., 2009; Orindi, 2005). In its Fourth Assessment Report (IPCC, 2007a), the IPCC projects an increase in temperature and changes in rainfall patterns leading to prolonged droughts and localized flooding.

Climate variability and change affects many socio-economic sectors such as agriculture, water resources, forestry, fisheries, ecological systems, human settlements, and health, with significant effects on national food security (Thornton, et al., 2006; UNDP, 2008). It is a significant threat to livelihoods since agriculture (crops, livestock and fisheries) is mainly rainfall-dependent and many farming systems are vulnerable with weak capacity for resilience. Climate change could, therefore, lead to the near collapse of food production structures in the region. The impacts of climate change on agricultural systems will vary by location. For example, while some areas will be affected by significant water shortages, others will be impacted by heavy rainfall. Smallholder agriculture, which is dominant in most parts of Africa, must adapt to the observed changing weather patterns and their associated climatic impacts (FAO, 2009; Thornton, et al., 2007). This is critical if agriculture is to continue contributing significantly to the overall goals of economic growth, wealth creation, food security and poverty reduction.

African technical and political leaders recognize the significance of and the need to address issues of climate change. One of the strategies adopted under Pillar I of the Comprehensive Africa Agriculture Development Programme (CAADP) is the adoption of sustainable land and water use practices, in order to contribute to CAADP's 6% annual growth of agriculture. Embedded in this strategy is the adoption of Climate Smart Agriculture (CSA) as a combined policy, technology and financing approach to achieve sustainable agricultural development under climate change. The concept implies agriculture that sustainably enhances productivity and resilience (adaptation), reduces or eliminates greenhouse gases (mitigation), and enhances achievement of national food security and development goals (FMARD, 2014). By incorporating climate change adaptation and mitigation into agricultural development planning and investment, African countries can sustainably increase agricultural productivity and enhance resilience for reduced food insecurity and poverty. In the short term and in direct response to the concerns of rural communities, climate smart agriculture can minimize the effects of extreme rain conditions (drought or floods), thereby stabilizing production systems.

The Forum for Agricultural Research in

Africa (FARA) is currently implementing a new Strategic Plan and Medium Term Operational Plan (MTOP) covering the period 2014–2018. The Strategic Plan and MTOP are premised on *Enhancing African Agricultural Innovation Capacity* as a pathway to broad-based improvements in agricultural productivity, competitiveness and market access. It addresses three strategic priorities, namely:

- *Visioning Africa's agricultural transformation* through foresight, strategic analysis and partnerships. This will enable African agricultural stakeholders determine how to develop and plan agricultural strategies based on evidence and combined strength of all stakeholders.

- *Integrating capacities for change* by making the different actors aware of each other's capacities and contributions, and exploiting relative advantages for mutual benefit, while also strengthening human and institutional capacities.

- *Creating an enabling environment for implementation* through advocacy and communication. This will ensure that African policy makers obtain evidence needed to generate enabling policies and ascertain stakeholder support required for implementation.

The implementation of feasible CSA policy and programmes is an innovative approach for sustainably increasing the productivity of crops, livestock, fisheries and forestry production systems; improving livelihoods and income for rural people; while at the same time contributing to the mitigation of the effects of climate change. This approach combines the development of social resilience with ecological resilience, promotes environmentally friendly intensification of farming and herding systems, and supports sustainable gathering systems. Increased productivity, boosted through CSA, is accomplished through adequate combination of technologies, policies, financing mechanisms, risks management schemes and institutional development. CSA should, therefore, be embedded into identified development pathways for transforming food systems, landscapes, farming systems and practices adapted to communities. There is a wide range of agriculture-based practices and technologies that have the potential to increase food production and the resilience of food production systems, as well as reduce emissions and/or enhance carbon storage in agricultural soils and biomass. However, even where synergies exist, this may entail significant costs, particularly in the short-term, for smallholders.

This report is drafted in response to the objectives of FARA for a baseline survey to generate data and information on CSA. With support from NORAD, the survey was carried out in collaboration with sub-regional organizations (SROs) such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA), and Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD),. The report provides information that can be used to support evidence-based CSA policy, programme design and performance monitoring to promote accelerated scaling of CSA in the Eastern Africa region. The specific objectives addressed in this report are to:

i) Identify, document and collect baseline data and information on successful climate smart agricultural practices for scaling up and out-scaling.

ii) Document and collect data and information on policies that promote climate smart agriculture and various policies, strategies, plans and programmes linked to agricultural development.

iii) Identify existing gaps and investment opportunities where CSA can intervene within the CAADP framework and CAADP- CSA framework.

iv) Determine the drivers, challenges/ constraints and opportunities for scaling up and scaling out of CSA practices in Africa.

v) Ascertain the priority crops and livestock that are suitable for CSA practices across the different agro-ecologies in Africa.

# 2. Methods

## 2.1 Inception Meeting

An inception meeting between the consultants and the FARA team took place on 29 May 2014. The purpose of the meeting was to obtain a common understanding of the terms of reference and to develop tools for collecting data for this report.

## 2.2 Sources of Data

The study is based on information from primary and secondary data. Primary data was obtained from key informants, such as experts in the field of climate change and CSA, through administration of questionnaires and/or rapid participatory surveys. Desk-based literature reviews provided secondary data on the socio-economic characteristics of African farmers, food production systems, climate change adaptation and mitigation, and policies and national plans.

To summarize, the survey consisted of the following stages:

i) Literature review: Desk-based study on information from national and international sources and a review of existing grey and published literature on adaptation to climate change, mitigation of GHG emissions, CSA and policies related to climate change, food security, and rural development.

ii) Key informant interviews: Interviews with policy-makers, researchers, and farmers organizations involved in designing and implementing agricultural development and climate change adaptation policies in the three East African countries. The information was obtained from nationals of the selected countries and field visits.

## 2.3 Study Area

The study covers three East African countries of ASARECA, i.e., Kenya, Ethiopia and Uganda. The main agro-ecological zones of interest are the dominant agro-ecological zones (AEZs) in the region, namely, the highland sub-humid, sub-humid and Highland semi arid areas. In Ethiopia, the highland semi-arid zones are important.

## 2.4 Data Collection

Data and information were collected from key informants on:

- Adaptation and mitigation measures in use
- Case outlines of successful climate smart agriculture
- Observed temperature and rainfall
- Vulnerability to climate change and impacts
- Socioeconomic and demographic characteristics of farmers
- Crop yields
- Indicators of development and governance
- National policies and strategies

The data was collected with reference to the 2013 financial year as the baseline year for this report, except as otherwise specified.

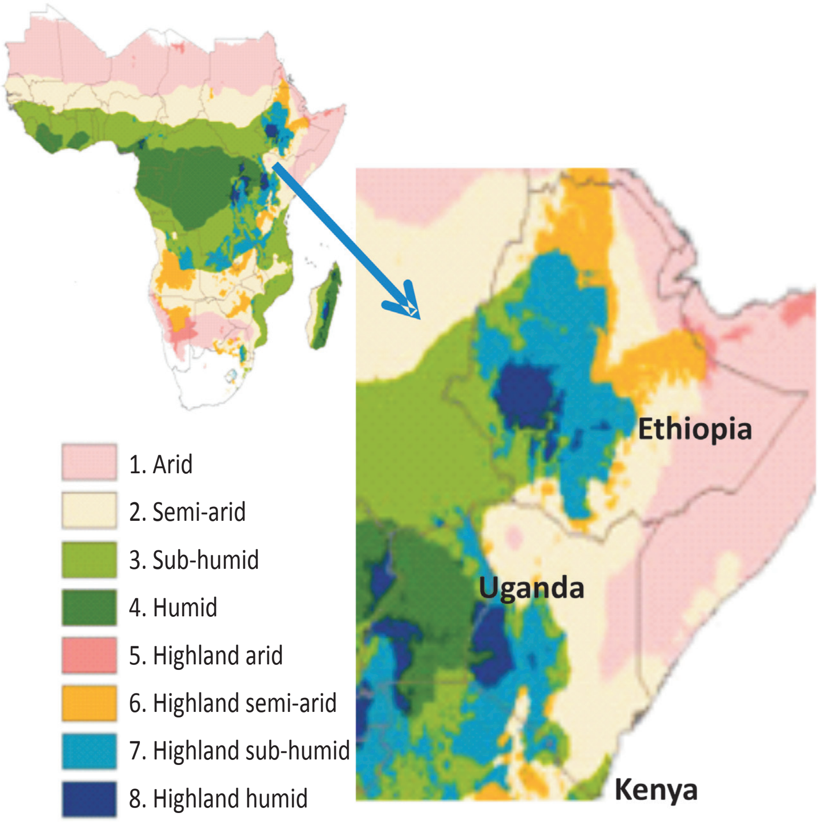



***Figure 2.1: The African agro-ecological zones (Adapted from: Harvest Choice/IFPRI, 2009)***

# 3. Climate Change and its implications for Agriculture and Livestock productuion

## 3.1 Changing Climate Scenarios in Eastern Africa

Considerable uncertainty about future climate variability and change exists in relation to large-scale precipitation dynamics simulated by General Circulation Models (GCMs) for Africa (Hudson and Hewitson, 1997; Joubert and Hewitson, 1997; Feddema, 1999). However, there is evidence of changes in climate from past to present. From the beginning of the last century, there were two contrasting climatic episodes in Africa; drought and desiccation at the beginning of the 19th century followed by favourable climatic conditions in the arid and semi-arid regions of West Africa. Models suggest that the earlier desiccation could have resulted from a 12 percent reduction in rainfall from the present mean, or a 6 percent reduction accompanied by a small reduction in cloud cover. The improved conditions in the mid-nineteenth century could have been accounted for by a 10 percent increase in rainfall, or 5 percent if there was a small increase in cloudiness (Nicholson and Yin, 2001). In the period of 1931–1960, rainfall changed substantially up to 1990, most notably over tropical North Africa where mean rainfall declined by up to 30 percent during 1961–1990. This decline in Sahel rainfall is unparalleled in the world. In the East African region, rainfall increased (most notably in equatorial East Africa) with a 15 percent increase resulting in a series of wet years in the 1960s.

The climate of the Eastern Africa region is changing, with increases in extreme weather events and increased rainfall during the months of November and December. Significant reduction in the severity of 10-year driest seasons is also evident in almost the entire East African region. The region experiences bimodal rainfall patterns, with Long Rains (from March to May) contributing more than 70 percent of the annual rainfall and the Short Rains ( between October and December) less than 20 percent. Much of the inter-annual variability comes from Short Rains, with a coefficient of variability at 74 percent compared with 35 percent for the Long Rains (WWF, 2006). In 1998, many countries in East Africa had up to ten times the normal amount of rain. In 2007, floods in Kenya, Uganda and parts of western Ethiopia rendered about 600,000 homeless, the majority of whom were from Uganda and Ethiopia. The magnitude of simulated reductions in severity of these dry extremes is comparable with those of mean precipitation rates. Larger reductions are found in northern Kenya, Uganda and the Lake Victoria basin.

### Ethiopia

Ethiopia is a large complex country with complex patterns of rainfall and livelihoods (Livelihoods Integration Unit, 2010). The rainfall seasons vary in different areas. In the eastern Somali region, rains occur twice a year: (i) during the March–June Belg season and (ii) during the October–December Deyr season. In the south-central part of the country, most areas receive both Belg and summer (June–September) Kiremt rains. Between the mid-1970s and late 2000s, data from quality controlled station observations showed that Belg and Kiremt rainfall decreased by 15–20 percent across parts of southern, southwestern, and southeastern Ethiopia. The wet and dry decades, calculated using mean rainfall from ERA-40 data for 1958-2001, show that the anomaly is positive for most parts of central, eastern, northeastern Ethiopia, especially for July and August which are the peak months of the Kiremt season (Endalew, et al., 2007). During the past 20 years, the areas receiving sufficient Belg rains have reducedby 16 percent.

The average rise in temperature since 1900 has been 1°C. The average annual minimum temperatures from 40 stations throughout the country for the period 1951-2006, show that there has been a warming trend over the last 55 years, increasing by about 0.37°C every decade. The mean annual rainfall variability and trend observed over the country in the period 1951-2006 shows that the country has experienced both dry and wet years. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country (NAPA, 2007).

Modeling of the future Climate of Ethiopia: The observed warming trends are more likely to continue than rainfall trends. Recent rainfall decreases may be linked to warming of the Indian Ocean and, therefore, likely to persist for at least the next decade (USAID, 2012). The IPCC forecast on precipitation levels show a long-term increase in rainfall in Ethiopia, despite the short and medium term observations of frequent dry periods with extreme rainfall levels. The average change in rainfall is projected to be in the range of 1.4 - 4.5 percent, 3.1 - 8.4 percent, and 5.1 - 13.8 percent over the next 20, 30, and 50 years, respectively, compared to the 1961 to 1990 normal (EEA, 2008).

## Kenya

Temperature trends between 1960 and 2006 show general warming over land locations, except for the coastal zone where cooling trends are observed. The minimum temperature has risen by 0.7 – 2.0°C and the maximum by 0.2 – 1.3°C depending on the season and the region. In areas near the Indian Ocean, maximum temperatures have risen similarly to other areas, but minimum temperatures have either not changed or have become slightly lower. The Fourth and the Fifth Assessment Reports of the Intergovernmental Panel on Climate Change indicate extreme precipitation changes over Eastern Africa. In Kenya, for example, 2003 was the wettest year in 70 years, followed by a drought in 2006 when the country received only 50 percent of expected rainfall.

Compared to the 1961 - 1990 average temperatures, a medium-high emissions scenario shows warming of approximately 4°C by the end of the century. Under a business-as-usual scenario, with no policy changes to reduce global emissions, the average warming across all models shows an increase of approximately 4.5°C by the same period, with individual models showing increases approaching and exceeding 6°C. With ambitious global greenhouse gas emission reductions (represented by RCP2.6), some models show a rise in temperatures by 1°C, while others show increases of 2°C. Precipitation is projected to increase in most parts of the country, but the higher variability is of more concern.

## Uganda

Mean annual temperature has increased by 1.3°C since 1960 at an average rate of 0.28°C per decade. Observations of rainfall over Uganda show statistically significant decreasing trends in annual and March-April-May (MAM) rainfall at an average rate of 3.4mm per month (3.5 percent) per decade. This trend is strongly influenced by particularly high rainfall totals in 1960-61. In addition, MAM rainfall has decreased by 6.0mm per month per decade (4.7 percent).

Using GCM models, the mean annual temperature is projected to increase by 1.0 to 3.1°C by the 2060s, and 1.4 to 4.9°C by the 2090s, with the projected rates of warming greatest in the coolest seasons. There will be increases in the frequency of days and nights that are considered 'hot' in the current climate by 15-43 percent of days by 2060s. Projections of mean rainfall indicate increases in annual rainfall of -8 to +46 percent by the 2090s, with an average change of +7 to +11 percent.

## 3.2 Vulnerability and the adaptive capacity of Eastern African farmers

Vulnerability to climate change may result from exposure to associated external risks such as floods, extreme temperatures, droughts, frosts, and other climate hazards, or internal factors that minimize the capacity of farmers to effectively respond to hazards (Chamber, 1983). Farmers across the Eastern Africa region lack the means to cope with the deleterious effects of climate change. O'Brien and Mileti (1992) examined vulnerability to climate change and observed that the resilience of populations is dependent on the structure and health of the population. Socio-economic factors of farmers across the region make them vulnerable to climate change. Age, for example, is an important factor sincefarmers in Kenya are on average 55 years old, while their counterparts in Uganda are 50 years (Njarui, et al., 2012) and mainly male dominated (particularly in influencing farming decisions). The factors in Table 3.1 summarize the socio-economic characteristics of the farmers in the three countries.

***Table3.1: Factors influencing vulnerability of East African farmers to climate change***

| Vulnerability Indicator | Countries | | |
|---|---|---|---|
| | Ethiopia | Kenya | Uganda |
| Annual population growth (2012) | 2.6 | 2.7 | 3.4 |
| Life expectancy (2011) | 62.3 | 60.4 | 58.6 |
| Population density/per km2 (2011) | 89.4 | 73.8 | 175.9 |
| Economic Vulnerability Index (EVI) (2012) | 33.5 | 26.6 | 36.2 |
| Human Asset Index (HAI) (2012) | 28.2 | 59.1 | 45.8 |
| Humanity development Index (HDI) (2012) | 0.396 | 0.519 | 0.456 |
| Share of value added (Agric/fish/forests, hunting) (2009–2011) | 44.7 | 29.3 | 24.7 |
| Percent arable land and under permanent crop | 1.1 | 0.9 | 11.3 |

(Source: United Nations Conference on Trade and Development (UNCTAD), 2014)

The high population growth rates in the region, where arable land is already experiencing increased population densities, and a low Human Asset Index (HAI) results in high social vulnerability (Adger, 1999). The Economic Vulnerability Index (EVI) of the region is low because the seven indicators used to construct this index are not favorable across the three countries:

i) High population density

ii) Dilapidated infrastructure influencing access to markets

iii) Low participation in export markets by the locals

iv) High shares of agriculture, forestry and fisheries in gross domestic product, sometimes up to 100 percent

v) Displacementsdue to natural disasters (e.g., floods) and conflicts

vii) Unstable agricultural production since the sector is mainly dependent on variable natural climatic factors

viii) Unstable exports of goods and services. The low levels of the Human Asset Index (HAI) and Economic Vulnerability Index (EVI) limits coping capacities of to the current and future climatic stress

It is also important to note that vulnerability of African farmers to climate change impacts is influenced by the strength of existing institutions and governments' infrastructure that support farmers in coping with climate change effects (Table 3.2).

***Table 3.2: Factors influencing vulnerability of East African governments to climate change***

| Institutional and country's vulnerability indicator | Country | | |
|---|---|---|---|
| | **Ethiopia** | **Kenya** | **Uganda** |
| Gross National Income (GNI) per capita ($) (2012) | 1,017 | 1,541 | 1,168 |
| Total Debt stock as percent of GNI | 24.3 | 31.1 | 22.5 |
| Real Gross Domestic Product (GDP) growth rate (2013) | 7.7 | 2.9 | 2.5 |
| Gross Capital Formation - percent of GDP (2011) | 32.1 | 21.7 | 25.0 |
| Gross Domestic Savings - percent of GDP (2011) | 17.2 | 4.5 | 6.5 |
| External Resource Gap percent of GDP (Foreign direct investment, net inflows) (2011) | 2.0 | 0.8 | 5.8 |
| Foreign Direct Investment (FDI) inflows million USD (2012) | 278.6 | 258.6 | 1205.4 |

(**Source:** United Nations Conference on Trade and Development (UNCTAD), 2014)[1] Impacts of climate change on Crop Systems

The interaction between climatic parameters such as temperature, rainfall amount and pattern, influences crop growth and ultimately, crop yield. Across the region, loss/reduction in crop yields, degradation of the ecosystem and loss of biodiversity are common features in all zones that are associated with changing climate. Agro-ecological zones and crops will be affected differently by climate change, with reducing yields in some areas and increasing yields in others, for different crops grown. Projected

[1] Including Human Development Report (2013), World Bank (2014), United Nations Committee on Development Policy (2012)

temperature increases are likely to lead to increased evaporation which will affect food production systems. The degree of evaporative loss depends on factors such as physiological changes in plant biology, atmospheric circulation, and land-use patterns. Past El Nino events and warm sea surface temperatures, for example, have been correlated with more than 60 percent of the change between the above and below-average agricultural production of maize (Patt, et al., 2005).

As predominantly agricultural based economies, the economic growth of the three study countries will be influenced by the effects of climate change. Studies carried out in Ethiopia show that the occurrence of droughts and floods reduce Ethiopia's annual growth potential by more than one-third (Grey and Sadoff, 2006). The droughts reduced Ethiopia's agricultural production by up to 21 percent, leading to a 9.7 percent fall in GDP (World Bank, 2006). As a result, food prices have increased, leading to generally negative effects on the economy.

Climate change will lead to increased climate variability causing fluctuations in crop production. Crop and livestock losses resulting from droughts and floods have been estimated at US$266 per household (Stern, 2007). With the use of CliCrop model, the changes in $C^{O}2$ concentration, precipitation, and temperature was used to estimate the changes in production (yield) for each year for the major crops grown in Ethiopia (Figure 3.1). The changes in yields are due to either the lack of available water (dry years) or the overabundance of water (wet years) that causes water logging. Climate impacts are significant, although variable, over regions and crop type, and increasing over time. The first order effects of the impacts of climate change include reduction in income, employment, savings, and investments. On the other hand, higher $C^{O}2$ levels result in increasing yields. The yields for some crops like wheat and soybeans could increase by 30 percent or more under a doubling of $C^{O}2$concentrations. The yields for other crops, such as corn, exhibit a much smaller response (less than 10 percent increase) (CCSP, 2008).

In Kenya, a rise in sea-levels of 1m will cause losses of almost US$500 million for three crops (mangoes, cashew nuts and coconuts), while an increase of temperature by 1.2$^{O}$C can make tea cultivating areas unproductive if changes in precipitation does not adequately compensate for the loss of moisture through evaporation (Republic of Kenya, 2002). According to the NAPA of Uganda, an increase in temperature by 2$^{O}$C would make most of the areas in Uganda unsuitable for coffee production.

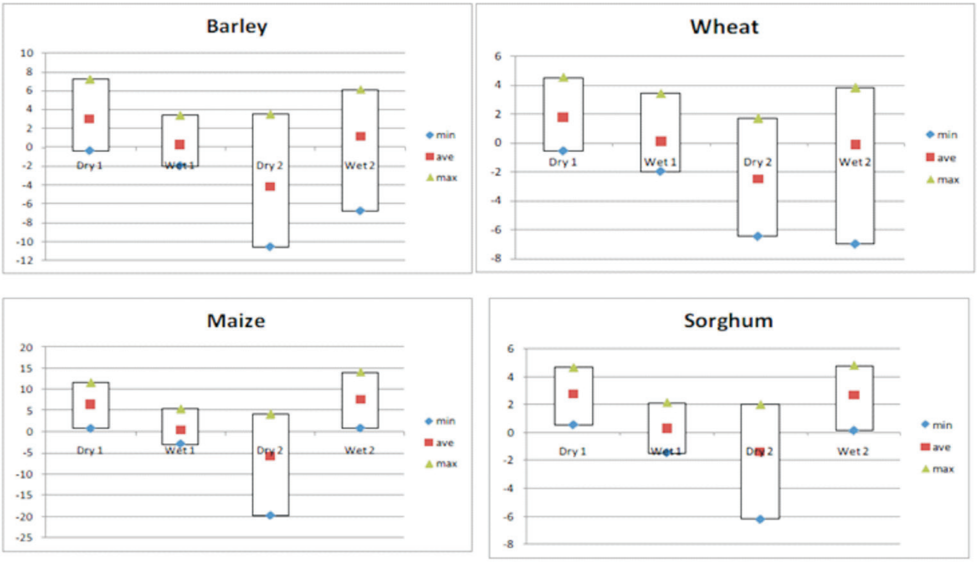



***Figure 3.1: Percentage yield deviations from no-climate change base (2006–2050) in Ethiopia***

## 3.3 Impacts of climate change on Fisheries

Climate change will impact on the fisheries, which have a critical thermal maxima and minima and cannot survive temperatures that exceed their threshold. Although tropical fishes can endure temperatures very near their temperature threshold, a slight (1–2$^{o}$C) increase in regional temperatures may cause the daily temperature maxima to exceed these limits (Roessig, et al., 2004). Studies in Lake Tanganyika show that the lake's productivity has decreased over the last 200 years (GTZ, 2009) although dwindling fish production in freshwater systems across the region are not only as a result of climate change, but also due to pollution and overfishing.

## 3.4 Impacts of climate change on Livestock Systems

Climate change affects livestock production through its effects on water and pasture availability, incidence of livestock pests and diseases and the distribution of livestock across the region. The direct effects of heat stress on livestock have not been extensively studied (Msangi, 2014); however, warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton, et al., 2009). Climate change is likely to benefit the small-scale farmers who keep small-livestock that are easy to substitute with drought tolerant species, as compared to the large-scale farmers whose production systems and investments are less flexible. A slight change in climate could render such investments unprofitable.

## 3.5 Implications for Markets, Finance and Policy

The change in length of growing period, as a result of rainfall and temperature changes will have implications for crop and livestock production and ultimately, affect trade. Regional and international trade flow patterns for key agricultural commodities could change from countries of higher agricultural yields and comparative advantage to countries of lower yields and less comparative advantage. Improved access to markets, both locally and internationally, would provide a driving force for increasing agricultural productivity. To counter the predicted decreases in agricultural production, risk management strategies, financial support in the form of investments and smart subsidies to support poor small-scale farmers in adopting CSA methods, should be considered by governments.

# 4. Successful Climate-Smart Agricultural Practices in East Africa

Climate-Smart Agriculture includes practices and technologies that sustainably increase productivity, support farmers' adaptation to climate change, and reduce levels of greenhouse gases to reduce future changes in climate. Across the Eastern Africa region, a number of CSA technologies exist but their appropriateness vary according to the farming system and agro-climatic zone or region. The sections below document the different CSA technologies found in the different agro-ecological zones. The CSA technologies found in these areas aim at improving the productivity of existing livelihood systems, enabling farmers become more resilient and produce food under changing climate, and contributing to the mitigation of future changes in climate.

## 4.1 Conservation Agriculture

Conservation Agriculture (CA) aims at minimizing disturbance during land preparation for growing crops. It is a combination of a wide range of tillage and cropping practices/technologies such as mulching, conservation tillage, relay cropping, intercropping and crop rotation. These mechanisms reduce physical and chemical degradation of the soils (IIR and ACT, 2005).

### Zero / conservation / minimum tillage practices

The objective of low tillage (LT) practices (including zero, conservation and minimum tillage) is to reduce the negative impacts associated with tillage, such as loosening of soils, removal of soil surface cover, destruction of soil structure (which makes it susceptible to soil erosion) and loss of nutrients to the atmosphere through no or minimal disturbance of the soils.  The increase in productivity associated with minimal soil disturbance results from increased conservation of soil moisture and increased soil organic matter (SOM) in the top soil (Kaumbutho and Kenzle, 2007). The net benefits will be positive from these low tillage technologies if the increase in plant growth parameters is adequate enough to compensate for the negative influence of compacted soils that hinder root development after seed germination, increase weed pressure and reduce water infiltration. Under LT, weed control can, however, be achieved with herbicides.

Another form of conservation tillage is reduced tillage, where there is minimum disturbance of the soil in areas where seeds will be planted, either in rows, planting holes or small basins. This reduces the negative impacts of no tillage and improves root growth and penetration, and water infiltration, while maintaining surface mulch and slowing down decomposition of organic residues. Reduced tillage can be achieved through either *ripping* or small planting basins. Under *ripping*, a ripper is used to break clogs along the planting rows. Small planting basins that collect and store rain water are made, measuring 30-cm long and 20 cm deep at 70 cm spacing along the planting rows and 90 cm apart between rows to form rows of small basins. Seeding and fertilizer application is done in each basin. The spacing may depend on the requirements of the crops to be planted. Eight to ten maize or 10 - 20 bean seeds can be planted in a basin. Adoption of conservation agriculture was, however, reported to be low mainly due to lack of training, poverty and land ownership issues (Kaumbutho and Kenzle, 2007).

## 4.2 Crop Diversification and Cropland Management

One of the major sources of greenhouse gases in the atmosphere is the application of fertilizers to agricultural land. Nitrous oxide ($N_2O$) is emitted when nitrogen in synthetic fertilizers is added to the soil. The nitrogen stimulates microbes in the soil to produce more nitrous oxide, thereby increasing greenhouse gas emissions. Nitrous oxide is the third most important greenhouse gas, after carbon dioxide and methane, but has up to 300 times more warming effects as compared to carbon dioxide. The increased use of nitrogen-based fertilizers has resulted in the increase in nitrous oxide emissions in recent years. African production systems, however, are not responsible for the increase since properly synchronizing the timing of fertilizer application will result in the release $N_2O$ only after meeting the crops requirements. In addition, small-scale farmers across the region have been applying fertilizers at rates lower than recommended (Kipkoech, et al., 2008). African farmers could, however, still contribute to the mitigation of climate change through the adoption of technologies that reduce emissions or absorb green house gases.

The crop management technologies include all technologies that utilize crop diversity and their unique characteristics that may provide synergies in crop production. Across the region, there is a general shift away from mono-cropping among small scale farmers.

### Cover crops

Cover crops help to loosen up the soil, conserve moisture, reduce soil erosion, reduce labour, and increase nitrogen in the soil (Mariki, et al., 2011). With increasing temperature and dwindling rainfall amounts across the countries, the cover crops support food crop production in areas that are normally difficult to farm on. Leguminous crops (either grown together with food crops or solely as a fallow crop) are the most common cover crops and include Lablab - *Lablab purpureus* (L.) or *Dolichos lablab* (L.), Velvet bean *(Mucuna pruriens)*, Cowpea *(Vigna unguiculata)* and common types of beans. Crotalaria species *(Crotalaria ochroleuca* and *Crotalaria grahamiana)*, *Mucuna pruriens* and *Canavalia ensiformis* have been successful in Kenya and Uganda, with significant increase in maize yield following sole cropping of the fallow crops (Delve and Jama, 2002; Kaizzi, et al., 2002). The increase in production from using cover crops is so high that some scientists believe that leguminous crops could entirely substitute inorganic nitrogen fertilizer at the low average[2] of the farmers in the region (Beckeret, al., 1995). Indeed of the nitrogen derived through Biological Nitrogen Fixation (BNF), about 43 percent in *Mucuna* contributes the nitrogen requirements at moderate levels of output under favorable conditions (Giller, et al., 1997). Other crops used as cover crops, either at planting or during fallow periods, include *Sesbania sesban* (L), *Leucaena leucocephala* (cv Cunningham) and *Cajanus cajan* (Pigeon pea). The capacity of the leguminous cover crops rests in its high affinity for association

[2] African farmers often apply inputs at rates less than what is recommended (Kipkoech et al., 2008).

with several *Rhizobia* in the soil causing formation of numerous and large nodules in the plant roots to fix nitrogen.

The challenges in using cover crops are that it may be difficult to achieve net nitrogen fixation, especially if fixed nitrogen is less than what is required by the succeeding crops. The adoption of cover crops is also affected when the cover crops cannot be used as food or fodder crop, or where environmental factors affect the growth of the cover crops during the off-seasons. When crop growth is not well synchronized with the release of nitrogen by the cover crop, the nitrogen fixed is lost through leaching or denitrification.

## Productivity of cover crops in the region

The CSA technologies that use management options are available for all agro-ecological zones of the region, but the crop types will vary from one ecological zone to the other. The main driving force is the cover crop's moisture requirement. Cowpea and Lablab do better in low rainfall than high rainfall areas, while *Mucuna* performs better in high rainfall areas (Tumbo, et al., 2012).

Experimental studies in western Kenya show that the use of cover crops in farming systems benefited farmers in areas experiencing moisture stress, such as in the semi-arid areas. Two-season experiment in striga infested semi-arid areas of western Kenya showed that cover crops using Lablab and velvet beans *Mucuna (Mucuna pruriens)* in combination with reduced tillage, gave significant greater maize yields of 2.37 to 2.96 t/ha as compared to no-cover crops and conventional tillage, which yielded 1.75 t/ha (Nzabi, undated). The yield increase is due to reduced moisture stress, reduced erosion, reduced pest stress and the addition of plant nutrients (Table 4.1). Cover crops provide additional productivity by supporting other systems such as animal fodder and bees farming during off-season of crops.

***Table 4.1: Potential N-fixed by cover crops in Eastern Africa region***

| Types of cover crops | Ecological adaptation | Nitrogen added* | Reference |
|---|---|---|---|
| Lablab (*Lablab purpureus* (L.), Synonyms: *Dolichos lablab* L. | Tropical legume, tolerates low soil fertility, adapted to wide range of soil types, tolerates drought once established | 220kgN/ha | Valenzuela, 2002 |
| Velvet bean (*Mucuna pruriens*) | Tropical legume originated from India | 150kgN/ha | Carlo, 2009 |
| Cowpea (Vigna unguiculata) | Tropical legume, hot moist climate, slightly tolerant to low soil fertility, heat, and dry conditions | 130kgN/ha | Valenzuela, 2002) |
| *Sesbania sesban* | Tropical legume, hot moist climate, tolerant to low soil fertility | 250kgN/ha | Onim, 1986 |
| Pigeon pea (*Cajanus cajan*) | Tropical legume, hot moist climate, slightly tolerant to low soil fertility | 120kgN/ha | Onim, 1986 |

## 4.3 Agro-Forestry

Integrating trees/shrubs plants in agricultural lands for both crop production and grazing has been going on over the decades. The objectives of agroforestry have ranged from improving soil cover to conservation of biodiversity and fixation of plant nutrients, especially nitrogen (Kitalyi, et al., 2011). The arrangement of the tree crops in the farmland is done in a way to reduce competition for light, food and water with the planted crops. Trees can be planted on the edges, together with crops on the crop land, or in areas of the farms that are highly vulnerable to soil degradation, resulting in improved land productivity over the long-run. Some of the common crops used for agro-forestry are *Sesbania sesban, Crotalaria grahamiana* and *Tephrosia vogelii*, successfully used in Kenya (Kitalyi, et al., 2011). Other common agroforestry trees are *Moringa oleifera, Senna siamea, Senna spectabilis, Acacia auriculiformis, Leucaena leucocephala and in some provenances, Gliricidia sepium and Acacia albida (Faidherbia albida). In the dry areas, Acacia albida (Faidherbia albida)* is often intercropped with sorghum and millet. It is used in Kenya and Ethiopia mostly in areas with altitudes ranging from 270 – 2700 m above sea level with mean temperature of 18-30$^{O}$C and mean annual rainfall of 250 - 1200 mm. Agroforestry can be practiced in several forms: dispersed trees on cropland, compound farming (home gardens), alley cropping, improved fallows or as contour vegetation strips. The 'fertilizer' trees can be applied in several options including, (i) during fallow, in rotations with cereal crops, (ii) intercropping, and (iii) harvesting the trees and applying as mulch, green manure or compost (ICRAF, 2011).

***Table 4.2: Grain yield and above-ground biomass of maize in the agro-forestry treatments***

| Species (Above-ground) | Biomass (percentage of sole maize) | | Grain yield (percentage of sole maize) | |
|---|---|---|---|---|
| | Naro Moru | Thika | Naro Moru | Thika |
| ***G. robusta*** | 93 | 79 | 86 | 64 |
| ***A. acuminata*** | 89 | 97 | 79 | 99 |
| ***P. fortunei*** | 96 | 107 | 95 | 100 |

Experiments held in Kenya, expressed as a percentage of the corresponding values for sole maize during the 2001–2002 short rains (Source: Adopted from Muthuri et al, 2005)

The fertilizer trees contribute to climate change mitigation by sequestering about 2.5 to 3.6 tons of above ground carbon per hectare per year (Nyadzi, 2004). In rainfall areas of 300 - 500mm (semi-arid), cropping with tree crops such as *Guiera senegalensis* and *C.spectabilis* has resulted in increased millet yields of about 245 percent and groundnut yield of 20 percent; increased carbon stocks in soils and biomass; increased incomes; reduced vulnerability to droughts; and reduced wind erosion. The use of the *Faidherbia albida* system in Senegal, for example, which involves crops/livestock integration resulted in the increase of millet and groundnut yields by 150 percent and 44 percent, respectively; increase in carbon stocks of 60 percent; increased incomes; and reduction in droughts due to increased relative humidity, reduced potential evapotranspiration, and reduced temperatures. In Zambia, the practice increased maize yield from 2.8 tons/ha to 7 tons/ha (GoZ, 2007).

## 4.4 Reducing GHG Emissions in Rice Systems

A number of technologies have been developed to: (i) respond to the drying up of wetlands that have traditionally been used to produce rice, (ii) address the need to expand rice production beyond the wetlands to meet increasing demands, and (iii) mitigate climate change through reducing GHGs (nitrous oxide and methane) emitted from growing paddy rice. In Kenya, the average unit production under irrigation is 5.5 tons/ha for the aromatic variety, and 7.0 tons/ha for the non-aromatic varieties (G.O.K, Export Processing Zones Authority, 2005). The introduction of new varieties has increased rice production by expanding to areas that were initially difficult to produce on. The challenge has been promoting upland rice varieties to upland communities who never produced rice before. The System of Rice Intensification (SRI) method has the potential to increase yield, reduce demand for water, improve the livelihoods of the farmers (Kipkorir, 2012), and remove the inefficiencies in rice production (Kim, et al., 2012).

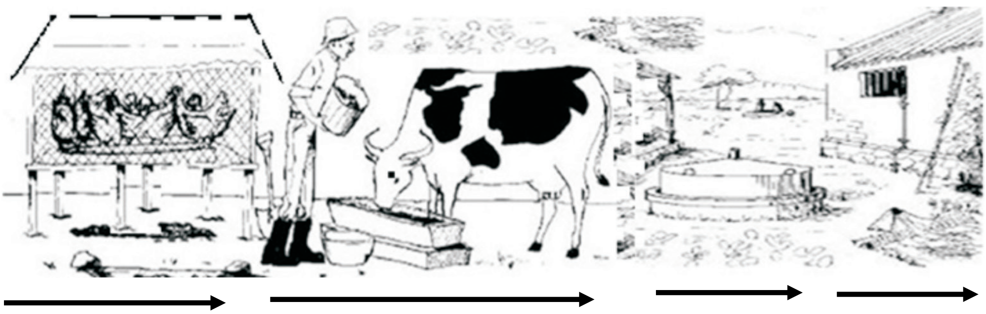
Some of the successful CSA rice production technologies in paddy rice include the use of a water-saving technology known as Alternate Wetting and Drying (AWD), designed by the International Rice Research Institute (IRRI) and partners in the Philippines, and promoted in western parts of Kenya and Eastern Uganda. The New Rice for Africa (NERICA) is inter-specific hybrid rice developed by the Africa Rice Centre (AfricaRice). The upland rice is climate smart option with yields exceeding that of the paddy rice, e.g., yielding an average of 2.6 tons per hectare under low input rain-fed conditions (Kijima, et al., 2006). The increase in productivity is also linked to high resistance to pests and diseases, and better tolerance of drought and infertile soils as compared to the paddy rice varieties.

***Plate 4.1: Upland rice (NERICA) growing in Eastern Uganda***

## 4.5 CSA technologies for livestock producers

Grassland and stocking rate management practices have the potential to help farmers adapt to climate change, contribute towards food security, and minimize land degradation. CSA technologies for fodder and livestock producers in the region include planting of high productivity varieties, drought tolerant and deeper rooted fodder grasses and/or legumes (Branca, et al., 2011) such as Superior *Brachiaria* bred cultivars (Mulato and Mulato II) and *Canavalia brasiliensis* that have been tested and promoted in Kenya (CIAT, 2013). In Ethiopia, different strategies and species for pasture and forage development have been selected and promoted (Alemayehu, 2002). The strategies include: strip establishment of forages, backyard forages, improved forages in stock exclusion areas, legumes sown over grazing areas, and perennial mixed grass/legume pastures. The most common forage crops are fodder beet, elephant grass mixed with Siratro and *Desmodiums, Rhodes/Lucerne* mixture, *Phalaris/Trifolium* mixture, and hedgerows of *Sesbania, Leucaena* and tree-lucerne. Controlled management of grazing land is achieved through stocking rate management in order to allow rejuvenation of grasses and reduce vegetation destruction (Branca, 2011). Applying vegetation management practices to grazing lands ensures that climate smart criteria are met.

Methane production in livestock systems is a major contributor of green house gas emission. Integrating livestock and crop farming in order to recycle nutrients can reduce GHG emission through the use of crop waste as livestock feed and vice versa (Rota, 2010). Crop residues can be used to feed animals and manure is returned to the farm to recycle nutrients, improve soil fertility and increase soil organic matter (SOM) (Rota, 2010). Poultry manure contributes significant amounts of calcium, phosphorus and potassium and numerous trace minerals (Ruffin and McCaskey, 1990) that eliminate or reduce the need to apply inorganic fertilizers in agricultural farms. The technology of using animal waste in nutrient cycle management has been applied mostly in urban and peri-urban farming in Ethiopia, Uganda and Kenya. Livestock keepers reduce GHGs from livestock by generating biogas from waste for cooking, which also reduces forest degradation through decreased firewood consumption (Pye-Smith, 2011). In Kenya, for example, biogas plants using livestock waste have been constructed for farmers, with support from the Netherlands Development Organisation (SNV).



*Droppings collected* *Droppings fed to livestock* *Animal waste biogas*
*Household use (Sludge taken to the farm)*
*biogas*

Poultry production has also been integrated in fish production across the region. In Kitui, Kenya, farmers obtained 670 kg per hectare fish yield at maturity (after three months) using only poultry manure without supplemental feeds. This is a 60 percent increase in yield compared to traditional methods of rearing fish. Studies of comparable poultry-fish integration systems in Bangladesh show an increase in egg, meat and fish production under the integrated system as compared to sole production systems (Table 4.3). Both production and processing of livestock generate by-products that can be used for aquaculture and qualifies as CSA technology through nutrients reuse, particularly from livestock manure (Little and Edwards, 2003). This involves the supply of elements such as nitrogen (N) and phosphorous (P), which stimulate the natural food web, compared to conventional livestock nutrition usage of feed ingredients that are fed directly to fish.

***Plate 4.2: An integrated poultry-fish production system in western Kenya***

***Table 4.3: Additional production of different components per farm under integrated pond management (average over 3 years) - (Robiul et al, 2009)***

| **Components** | **Production (kg)** | | |
|---|---|---|---|
| | Traditional management | Integrated management | Additional production (kg) |
| ***Poultry*** | | | |
| **Egg** | - | 14829 | 14829 |
| **Meat** | - | 84.06 | 84.06 |
| **Vegetables** | - | 777.33 | 777.33 |
| ***Fish*** | 91.20 | 393.00 | 301.80 |

The major limitation in this system is poor nutrient quality in crop residues and manure if not properly handled, which is insufficient for sustainable crop production (Rota, 2010).

**Livestock insurance scheme:** In Kenya, the International Livestock Research Institute (ILRI) launched an index-based livestock insurance scheme for pastoralists in Northern Kenya, with payments dependent on the death of livestock due to lack of pasture. The project monitors vegetation changes through satellite imagery and provides early warning to pastoralists to prevent degradation from overgrazing (Pye-Smith, et al., 2011). The scheme motivates farmers towards sustainable environments by considering the carrying capacity of the environment when making decisions on livestock production.

**Land tenure to facilitate rotational grazing:** Rotational grazing is necessary for meeting animal forage needs. The allocation of land to pastoralists for grazing is a starting point for obtaining improved rangeland management. This will encourage the pastoralists to manage the land and practice controlled grazing (Tumbo, et al., 2011). In some pastoral areas in Kenya, secure land titles are being provided. Animal harvesting, improved pasture, improved livestock breeds and ownership of land for grazing and pasture can be promoted to wider livestock keepers and contribute towards achieving CSA (Tumbo, et al., 2011).

Improving pasture can indirectly contribute towards improved agricultural lands by reducing the demand for crop residue to feed livestock and avoiding land degradation. Maintaining crop residues on the farms protects the soils and builds SOM long term.

## 4.6 Soil Fertility Management

The main limiting factor to crop production in the region is soil fertility, with large responses to only nitrogen and higher responses to nitrogen and phosphorus combined (Waata, et al., 2002). Options to improve the nutrient status of the severely low N and P soils include the use of inorganic fertilizers (FURP, 1994); organic resources (Lwayo, et al., 2001); legume-fallow and agroforestry practices (Amadalo, et al., 2002). The application of inorganic fertilizers, particularly N, to improve soil fertility, is responsible for the GHG emission contribution by the agricultural sector (Flynn, 2009). To ameliorate soil fertility, there are is a number of climate smart technologies.

**Precision agriculture:** In the past decades, fertilizer application has been based on blanket recommendations for specific regions. The FAO has recommended that blanket uniform fertility management packages should be avoided and specific packages for unique production constraints employed (FAO, 2001; FAO, 2006; GPNM, 2010). An accurate estimation of the amount of N fertilizer required per crop demand, for example, is essential for avoiding the build-up of $N^{O}3$- in the soil from excesses that increase the potential for NOx emissions (Flynn, 2009). Technical advice on the effective use of phosphorus,which influences root growth and development (Havlin, et al., 2005), leads to nutrient use efficiency. In a quest to improve fertilizer use efficiency and reduce costs, farmers, especially the large scale farmers in Kenya, are adopting soil testing to guide fertilizer applications across the agricultural farms. The system is, however, not yet widely used mainly because of the high costs of soil tests and the lack of adequate personnel to carry out the tests.

**Organic fertilizers:** Across the Eastern Africa region, organic fertilizers from household organic wastes and farm yard manure are the widely used form of fertilizers among small-scale farmers. The intensive cultivation of maize with high levels of inorganic fertilizer may lead to soil degradation (Bekunda, et al., 1997; Marenya and Barrett, 2009). Organic manure (including crop residues, tree leaves, green manure, compost, and animal manure) is a climate smart option that increases yield and also reduces the need for inorganic fertilizers that contribute to GHG emissions. Organic fertilizers can be used solely or combined with inorganic fertilizers in specific ratios. The combination of organic and inorganic fertilizers at half-half nutrient recommendations have a great potential to increase yield and soil health (Onyango, et al., 2000).

**Enhancing nutrient recycling:** There is a myriad of CSA technologies for soil fertility management to ensure efficient nutrient cycling. The N-fixing leguminous plants fix nitrogen from atmosphere through the symbiotic relationship with *Rhizobium* bacteria (Coskan and Dogan, 2011) and eliminate or reduce the need for application of fertilizers (Nicolas et al., 2006). Leguminous plants are intercropped with cereal crops such as maize. The *mbili* approach (alternating two rows of cereals with two rows of legumes) has been found to increase water use efficiency between cereals and legumes (Tugani, et al., 2002). A tremendous potential for contribution of fixed nitrogen to soil ecosystems exists among the legumes (Peoples, 1995). Out of the potentially 700 genera and about 13,000 species of legumes worldwide, only a portion (about 20 percent) been examined for nodulation and have the ability to fix N2 (Sprent, 1990).

**Fertilizer Micro-Dosing:** This technology involves the placement of small amounts of fertilizers in mounds of millet or sorghum, which, in the Sahelian zone, improves fertilizer use efficiency and biomass. Crop yield increases are up to 100 percent and farmers in the semi-arid and sub-humid zones have reported increased incomes (Tabo, et al., 2006).

**Fertilizer trees:** As discussed above, agro-forestry improves soil fertility. Fertilizer trees such as *Sesbania sesban, Crotalaria grahamiana and Tephrosia vogelii* are recommended and have been successfully used in Kenya (Kitalyi, et al., 2011), Ethiopia and Uganda.

## 4.7 Farmer Assisted Natural Regeneration

Farmers in the semi-arid zones allow tree *(Faidherbia albida or Piliostigma reticulatum)* stumps to regenerate and cut leaves are left on the surface. Food-for work is sometimes provided as an incentive. Over 5 million ha in the semi-arid Sahel have been restored with additional 500,000 tons of grain each year and enough fodder to support a number of livestock, thereby increasing food security for millions and enhancing their resilience to climate change (Lineger, et al, 2011; Neate, 2013). In semi-arid areas with 150-700 mm rainfall, assisted natural regeneration has resulted in increased yields of milletto more than 150 percent; improvement of carbon stocks in soil and biomass; increase in incomes; reduction in vulnerability to drought; reduction in wind erosion; and increase in wood production.

## 4.8 Best Adaptation Practices for Ecosystem Management

The Humbo Project is the outcome of collaboration across various organizations and continents and involves the World Vision offices in Australia, the World Bank, the Ethiopian Environment Protection Agency, local and regional government agencies, and the community. The Humbo Assisted Natural Regeneration Project has restored more than 2,700 hectares of degraded land in the impoverished highlands of southwestern Ethiopia, since 2007. Conventional approaches to reforestation require the costly replanting of trees from nursery stock. However, over 90 percent of the Humbo Project area has been reforested using Farmer Managed Natural Forest Regeneration, which encourages new growth from tree stumps previously felled but still living. Using this method, indigenous forest species, some of which are endangered, have been restored. It is expected that the sale of carbon credits under the BioCarbon Fund will provide an income stream of more than US$700,000 to the local communities over the next decade. Humbo is the first large-scale forestry project registered under the Clean

Development Mechanism of the Kyoto Protocol in Africa.

The Joint Program enabling preparedness and response to the hazards through climate monitoring and early warning systems, helps farmers to evade impacts of climate hazards in eastern Karamoja and the Mount Elgon region of Uganda. The programme is led by the Government of Uganda and brings together a wide range of partners including the World Food Programme (WFP), Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Capital Development Fund (UNCDF), United Nations Human Settlements Programme (UN-HABITAT), United Nations Population Fund (UNFPA), Office for the Coordination of Humanitarian Affairs (OCHA), and World Health Organization (WHO).

Pastoralism is an adaptive strategy evolved over hundreds of years to cope with spatial and temporal patchiness of forage and water resources in savannah, arid and semi-arid areas. McPeak and Barrett (2001) and McPeak and Doss (2005) indicated that during droughts, pastoralists move away with their livestock, provide supplementary feeds, or practice inter-house transfer as a means of adaptation to climate change. Herd accumulation is also a form of insurance against drought or disease.

The Index based livestock insurance (IBLI), presents an opportunity to overcome the impacts of drought and diseases. The IBLI pilot in Marsabit, Kenya, developed by ILRI, is based on the Normalized Difference Vegetation Index (NDVI), a satellite–derived indicator of the amount and vigor of vegetation, based on the observed level of photosynthetic activity.

Grazing management approaches include pasture reseeding to help regenerate depleted pastures. This may include the use of traditional pasture or improved pasture and fertilization. Some strategies for reducing vulnerability of pastoral livelihoods and improving their adaptive capacity are through development of fodder banks, designating conservation areas and marketing programs.

In November 2010, the Kenya Agricultural Carbon Project (KACP) became the first soil carbon project in Africa to sign an Emissions Reduction Purchase Agreement (ERPA) with the World Bank's Bio Carbon Fund. The project is operating in western Kenya, which is dominated by subsistence farms with an average of less than one hectare of highly degraded land. Implemented by Vi Agro-forestry, a Swedish non-governmental organization, the project is helping farmers adopt sustainable agricultural land management (SALM) practices, such as reduced tillage, use of cover crops and green manure, mulching, targeted application of fertilizers and agro-forestry. The project follows the World Bank's *Adoption of Sustainable Agricultural Land Management* methodology, which uses land management practices as a proxy for carbon stock changes. Under the Vi Agro Project, conservation agriculture, for example, which involves the use of minimum tillage, the retention of organic matter, and crop rotation, enables farmers to reduce their carbon emissions, increase crop yields and cope with climatic variability. Agro-forestry, which involves planting trees on farmland, can sequester carbon, improve soil fertility, reduce soil erosion, provide alternate pasture and raise smallholders' incomes. Farmers are educated to adopt climate-smart practices in order to realize the reduction in climate change risks.

## 4.9 Summary of the adaptation measures and Mitigation practices in use

A number of CSA technologies are in use in the different agro-ecological zones (AEZ) in Africa. Their potential contribution to agricultural production, adaptation and mitigation of climate change impacts are shown in Table 4.4. These are aggregated as production, resilience and mitigation.

## 4.10 Climate Smart Agriculture Best Bets

This section reports examples of Best Bet Practices based on the key informant survey. These include relevant success stories in Africa previously reported, for example, by Cooper, et al., 2013 and Neate, et al, 2013). Climate Smart Agriculture stands on the following pillars, namely, Conservation Agriculture (CA), crop diversification and cropland management, soil and water conservation/erosion control, more resilient food crops and risk insurance, fodder development – rangeland management and integrating livestock and crops and Integrated Soil Fertility Management (ISFM).

*Table 4.4: Contribution of climate smart practices to production, adaptation and mitigation*

| | AEZ[a] | Practices | Aggregate Assessment | | |
|---|---|---|---|---|---|
| | | | Production | Resilience | Mitigation |
| Soil fertility | S,SH,H | Nitrogen fertilizers (e.g, urea) | +++ | +/- | - |
| | S,SH,H, | Integrated nutrient management (e.g, microdosing, efficient fertilizer use) | ++ | + | - |
| | S,SH,H | Reduced residue burning | ++ | + | ++ |
| | S,SH,H | Reduced tillage/no till | + | + | + |
| | | Green manures (reduced fallows) | +++ | ++ | |
| | S,SH | Fertilizer trees (e.g, *Faidherbia*) | +++ | +++ | +++ |
| | SH,H | Conservation agriculture (mulch, no till) | ++ | ++ | ++ |
| | | Conservation Agriculture with fertilizer trees | +++ | ++ | +++ |
| | | Grain, livestock, and fertilizer tree integration | +++ | ++ | ++ |
| Genetics | S,SH,H | Improved crop varieties (breeding and engineering) | ++ | ++ | + |
| Water use | | Water pumps for irrigation (petrol) | +++ | ++ | -- |
| | S,SH,H | Irrigation techniques (amount, timing, technology) | ++ | ++ | +/- |
| | S,SH | Microcatchment (e.g, zai, microbasin, terracing) | ++ | ++ | |
| | | Rainwater catchment, storage, delivery (e.g, farm pond) | ++ | ++ | |
| Livestock | S,SH,SA | Rotational grazing | + | ++ | +++/--- |
| | S,SH,H | Improved breeding | ++ | | +++/ |
| | S,SH | Stocking density management (e.g, herd size/land area) | + | +++ | |
| | | Improved feed management (higher feed quality) | ++ | + | +++/- |
| | | Manure management (barn design) | ++ | ++ | +++/- |
| Information technology | S,SH,H | Planting date recommendation | ++ | ++ | |
| | S,SH.H | Sentinel warning system (droughts, pests) | + | ++ | + |

[a] AEZ presented in Figure 2.1 are combined in Table 4.4 for three zones which are: S = Semi-arid (incorporating Arid, highland arid, highland semi-arid and Semi-arid zones), SH = Sub-humid (sub-humid and highland sub-humid) and H = humid (humid and highland humid) zones following FAO (2013), CCAF (2014).

The benefits of improved crop varieties are primarily in terms of adaptation to the effects of climate change. Improved high yielding drought tolerant varieties of cereals, grain legumes, roots and tubers with tolerance to major disease and pests, developed by national programmes in partnership with CGIAR centres, are being used in all agro-climatic zones and countries. These crops provide increases in yield often more than 100 percent over local varieties. Well known examples are *nerica* (upland rice) and drought-tolerant maize varieties. When used in conjunction with the Sustainable Agriculture Land Management (SALM) practices, the improved varieties of maize, millet, sun flower, sorghum and cassava, considerably increase yields and productivity.

There are overlaps in the distribution of crops and livestock across the agro climatic zones and the distribution will further alter as rainfall, temperature and length of growing periods change. Sorghum and millet are the major food crops in the semi arid zone, and cowpea, groundnut, cotton and vegetables are other cropsof importance. In Kenya and Uganda, cattle are the major livestock, in Ethiopia, camels are also important. In a changing climate, small ruminants (sheep and goats) and poultry are essential because they are more adapted to harsh climate as compared to cattle. Markets also provide opportunities for farmers to diversify crop production beyond the traditional staple food crops such as fruit trees, legumes, vegetables and herbs (such as farm production of Aloe Vera in the arid areas of Kenya and Ethiopia). Table 4.5 below summarizes the successful climate smart agricultural practices.

*Table 4.5: Summary of successful climate smart agricultural practices in Eastern Africa*

| Climate Smart Agriculture Practice | AEZ | Indicators |
|---|---|---|
| Contour bunds/zai pits | Semi-arid | 100% increase in millet/ sorghum yields; establishment on 200,000 ha of lands |
| Stone bunds | Semi-arid | 25-60% increase in millet and sorghum yields |
| Farmer Assisted Natural Vegetation | Semi-arid | Adopted on > 5,000,000 ha of lands in the Sahel; improvement of food security |
| Association of *Guiera senegalensis* with crops | Semi-arid, humid, sub-humid | 260% increase in millet yields; 20% increase in groundnut yields |
| Parkland enclosures of trees, crops and livestock | Semi-arid | 160% increase in millet yields; 44% increase in yields of groundnut |
| Permanent ridges/ vegetative strips on contours | Semi-arid, sub-humid, humid | 14% increase in soil organic carbon; 15-103% increase in soil water storage after 2 years; 20-60% increase in returns to investments after 2 years |
| Seasonal weather forecasting | All zones | Millions of users benefiting through radio networks |
| Lowland cropping | Sub-humid, humid | 72-78% increase in yields of lowland rice compared to upland rice; 270% increase in returns to family labour |
| Agroforestry | All zones | Increase in carbon storage of 1680t $CO_2$/ha-42000t $CO_2$/ha at village level over 25 years |

**Source:** FARA Survey 2014; Cooper, et al., (2013); Neate, et al., (2013)

# 5. Policies and Actions to Promote Climate Smart Agriculture

## 5.1 National policies

A review of literature and policies across Eastern Africa indicates the lack of national policies specifically aimed at the adoption of climate smart agricultural technologies in the region. Across the three study countries, agricultural policies focus mainly on food security and poverty alleviation through diversified policy options. The Ethiopian government has prepared and adopted three successive poverty reduction strategy programs;

- Sustainable Development and Poverty Reduction Program (SDPRP) (2002/03–2004/05)
- Plan for Accelerated and Sustained Development to End Poverty (PASDEP) for 2005/06–2009/10,
- Growth and Transformation Plan (GTP) for 2010/11–2014/15

The policies recognize the need to address human development, rural development, food security, and capacity-building and are the priority areas of intervention in the SDPRP and under the present PASDEP. In addition to these, new strategic directions with emphasis on commercialization of agriculture and an emerging urban agenda are being promoted as a means to mitigate the challenges faced by the agriculture sector and the overall economy under GTP. Climate change is recognized as one of the challenges facing agriculture in Ethiopia as a result of its fragile climate and in Kenya where two-thirds of the country is considered arid and semi-arid land.

In Ethiopia, the lead institution shaping current climate response in agriculture is the office of the Prime Minister (DFID, 2011). In Kenya, climate change has acquired the status of a key national policy challenge, as demonstrated by the development of the:

- National Climate Change Response Strategy (NCCRS) in 2010 (GoK, 2010)
- National Climate Change Implementation Framework (NCCIF) (GoK, 2012)
- National Climate Change Action Plan (NCCAP) (GoK, 2013)
- Kenya Vision 2030 (GoK, 2007)

The policies recognize the critical importance of agriculture in national development (60 percent depend on agriculture and contribute 24 percent of GDP). Kenya's agricultural policy recognizes key areas of concern for *increasing agricultural productivity and incomes, especially for small-holder farmers*. There are no policies that directly relate to CSA, although all the elements of CSA (increase in productivity, resilience and mitigation of climate change) have been recognized in the NCCAP.

Some of the important policies for the agricultural sector that support CSA are the:

- Agriculture Act (Chapter 318)
- Agriculture (Basic Land Usage) Rules
- Agriculture (Farm Forestry) Rules
- National Land Policy
- Agricultural Sector Development Strategy

Under these policies are a number of

rules, such as the directive to have at least 10 percent tree cover on every farm (Agriculture Farm Forestry Rules of 2009), constitutional requirements on minimum and maximum land holding, the promotion of irrigation agriculture, extension officer-farmer trainings, and agricultural research policies. Most agricultural policies favour farming methods that rely more on external inputs and technologies than on locally adapted technologies and practices. The policies seem to provide regulatory frameworks but lack incentive systems to ensure that CSA is implemented. In most cases, existing policies target smallholder farmers who lack resources to test innovations such as CSA (since their primary goal is food security) and hence the slow rate of up-take of innovations. In view of policy propositions, enabling incentives can be direct (provision of seed, fertilizers, training on CSA, compensation for mitigation) and/or indirect (secure land tenure, provision of improved extension services and market and other infrastructural development). National agricultural sector actors are expected to align their climate change activities and plans to the NCCRS as stipulated in the NCCAP, and to the international policies such as those under debate in the UN Framework Convention on Climate Change (UNFCCC). The United Nations Framework Convention on Climate Change framework is expected to take care of international and regional concerns of climate change. Implementation of the NCCRS through the NCCAP strategies is in its formative stages and remains at the level of mainstreaming into government plans and development of implementation strategies.

In all countries surveyed, the Poverty Reduction Strategic Plan (PRSP) has been an important policy document in the preparation of National Budgets and National Adaptation Programmes of Action (NAPAs), and various programs such as the National Agricultural and Food Security Investment Plans (NAFSIPs). This has been critical for ensuring the inclusiveness of concerns of the majority.

## 5.2 National Adaptation Programmes of Action

Article 3 of the UN Framework Convention on Climate Change encourages governments to adapt to climate change. The NAPAs were intended for Least Developed Countries to plan and identify activities that respond to their urgent and immediate needs. Uganda and Ethiopia have prepared NAPAs detailing priorities, projects and policies intended to reduce national vulnerability and build adaptive capacity. Kenya, on the other hand, has prepared a similar and detailed National Climate Change Action Plan 2013-2017. It has been developed with the aim of implementing the National Climate Change Response Strategy (NCCRS) that was launched in 2010. The primary objective of the national adaptation actions and strategies was to identify short, medium and long-term actions and to address the impacts of climate change and variability within the context of economic development priorities, taking into consideration national and socio-economic conditions of the respective countries.

Using the NAPAs, Ethiopia based its prioritization on the poverty reduction potential and complementarities of national and sectoral plans. Table 5.1 below shows the priority sectors considered as vulnerable by the various countries in their action plans. The sectors prioritized by all three countries are agriculture, water and human health.

*Table 5.1: Vulnerable sectors prioritized in the NAPAs and National Communications of the three countries*

| Vulnerable Sector | Ethiopia | Kenya | Uganda |
|---|---|---|---|
| Agriculture | X | X | X |
| Forestry | | X | X |
| Livestock | | X | X |
| Energy | X | | |
| Water Resources | X | X | X |
| Human Health | X | X | X |
| Physical Infrastructure | | X | |
| Tourism | | X | |
| Coastal Zone Management | | | |
| Aquaculture and Fisheries | | X | |
| Adaptation strategies | | | |
| Water resource Management | | X | X |
| Promotion of Drought tolerant crops | X | X | X |
| Sustainable Agriculture and Land Management | | X | X |
| Environmental Conservation and Biodiversity/Land Restoration | X | | X |
| Early warning systems | X | | X |
| Diversification of Energy sources | | X | |
| Malaria Control | X | X | |
| Integrated Coastal Zone /Flood plain Management | | X | |
| Strengthening Community Awareness | X | X | |
| Livelihood diversification | X | X | |
| Water and Sanitation | | | X |
| Indigenous Knowledge | | | X |
| Disaster Risk Reduction/Risk Transfer | X | X | |

In the national plans, elements of CSA relate to improving resilience through the adoption of sustainable agricultural land management (e.g., agro-forestry technologies), water use efficiency, drought tolerant varieties and risk avoidance.

So far, the NAPAs have been among the most useful documents as inputs for Climate Smart Agriculture adaptation and mitigation issues. They have been useful in terms of documentation of rainfall patterns, temperature changes, vulnerability to climate change and sectoral analysis (i.e. agriculture, livestock, forestry, water, coastal and marine, and energy), AEZs and associated features such as crop production, soil status and climatic hazards, as well as proposed adaptation and mitigation measures. The NAPAs are one of the most powerful tools that some governments use to pursue national climate-resilient long-term visions. Adaptation plans, however, differ in their depthof coverage from country to country. However, not all countries have NAPAs in placeand their dates of publication differ.

## 5.3 Overcoming Major Obstacles and Accelerating the Implementation of National Action Plans

Sufficient and sustained funding is required for countries to plan for and implement adaptation. Article 4.4 of the UNFCCC, which is in support of adaptation in developing countries, states that "Developed countries shall assist the developing countries in meeting costs of adaptation to Climate Change". However, NAPA implementation cannot be entirely financed by international sources and African countries must also commit national resources. The three countries have attempted to increase allocation of national budgets to agriculture. In 2009, UNFCC indicated that the total cost of over 400 projects submitted for funding globally under NAPA was about US$2 billion, with only US$176 million pledged through the Least Developed Countries Adaptation Fund (LDCF) managed by Global Environment Facility (GEF). Governments in the region need to be innovative in leveraging additional funds to meet the costs of adaptation as a component of CSA. Other options include the Clean Development Mechanism and carbon markets beyond the 2012 Kyoto regimes.

## 5.4 Regional Policies Supporting CSA

A number of institutions have policies that promote CSA across the eastern Africa region, including regional blocks such as the Common Market for Eastern and Southern Africa (COMESA) and the South African Development Community (SADC). In these regional groups, CSA issues are addressed though the agricultural Research and Development (R&D) programmes. The sub-regional organization members (SRO) of FARA and ASARECA also partner with other agencies to promote CSA in the region. FARA, in response to NEPAD's request, developed the Framework for African Agricultural Productivity (FAAP). The purpose of FAAP is to guide stakeholders in agricultural R&Dto meet the objectives of CAADP Pillar IV for:

(i) Strengthening Africa's capacity to build human and institutional capacity
(ii) Empowering farmers
(iii) Strengthening agricultural support services

FAAP works at the continental, sub-regional and national levels to increase agricultural growth and to complement the CAADP. The SRO is positioned to contribute towards achieving the AU/NEPAD vision by using strong partnerships at all levels. It serves as a forum for promoting regional agricultural research and strengthening relations between National Agricultural Research Systems (NARS) in the sub-region, the Consultative Group for International Agricultural Research (CGIAR), and advanced agricultural research centers.

The East African Community (EAC) has also put together a climate change policy that has aspects of CSA and is consistent with the EAC protocol on environment and natural resources, sustainable development of

Lake Victoria and the UNFCCC frameworks. Among the EAC countries, decision making processes in CSA places Ministers for Agriculture and Food Security at the focal centre to ensure dialogue, synchronization of policy and programs between SROs and countries policies and targets. Engaging various stakeholders ensures that all stakeholders' opinions are integrated and well communicated. The process of engaging stakeholders ensures inclusiveness (small, medium and large scale farmers and various categories of actors including NARS, Universities, and financial institutions) and effectiveness of agricultural R&D programmes. While linkages with various international development partners assure joint support to promote CSA, linking with FARA ensures effective agriculture transformation across Africa (Akinbamijo, 2014).

## 5.5 Devolution of Strategies and Plans to Local Authorities

Nations have attempted to develop strategies that allow local authorities develop plans that could enable local implementation of CSA without necessarily requiring approval or support from the national authorities. Some of these strategies include the Rural Development Strategy, the Agriculture Sector Development Strategy and the general devolution in governance practiced in diverse forms across the continent. In the three study countries, a devolved governance system develops and implements county/regional policies (counties for Kenya and Uganda and regions for Ethiopia), and need to be consulted and incorporated in national and regional plans for effective implementation.

# 6. Existing Gaps and Investment Opportunities

## 6.1 The CAADP CSA Framework

There is widespread agreement that Africa faces significant challenges from climate variability and change and that agricultural production is closely tied to the management of natural resources, such as water and soil. NEPAD's Comprehensive Africa Agriculture Development Program (CAADP) ensures that climate change is mainstreamed into agricultural development. It provides an opportunity for incorporating CSA into Country and Regional Programmes through the development of the National Agricultural Investment Plans (NAIPs) and National Agricultural Food Security and Investment Plans (NAFSIPs), both key instruments in the CAADP process (Loada, 2014).

The AU-NEPAD Agriculture Climate Change Framework (AU-NEPAD, 2010) was designed as an agriculture/climate change strategic tool to (i) build capacity and address aspects of alignment, harmonization and financing amongst partners, (ii) help African countries define and determine agriculture/climate change agendas, and (iii) build informed leadership and responsibilities. Principally, CAADP delivers through four pillars:

i) Extending the area under sustainable land management and reliable water control systems
ii) Improving rural infrastructure and trade-related capacities for market access
iii) Increasing food supply and reducing hunger
iv) Agricultural research, technology dissemination and adoption

CAADP aims at assisting African nationals raise agricultural productivity by at least 6 percent per year, which is posssible through increasing public investment in agriculture to 10 percent of national budgets. The framework provides guidance to national and regional initiatives on programmatic approaches for knowledge generation, knowledge management and technology transfer and financing up-scaling. These are based on adaptation and mitigation measures, including sustainable land and agricultural water management. Specifically, the framework deals with the need for:

- Food production and commercialization
- Adaptation-mitigation integration
- Beneficial adaptation/mitigation measures
- Enhancing scientific capacity to improve adaptation-mitigation response, beneficial institutional policy actions
- Opportunities and challenges of up scaling

## 6.2 Gaps and Investment Opportunities to Intervene within CAADP Framework

Various challenges inthe following areas have been retarding the growth of Climate Smart Agriculture as anticipated by CAADP:

- Production and commercialization
- Integrating production and mitigation
- Scientific capacity to improve adaptation-mitigation responses
- Policy support for climate risk management
- Policy and institutional gaps
- Financing

The CAADP framework requires related national policies and institutions to be in place for the implementation of CSA. These challenges, therefore, present investment opportunities to intervene within the CAADP framework.

## Policies and institutions

All the NAFSIPs focus on production, but crop and livestock yields are still low and production has not kept pace with the demands of growing and urbanized populations. Commercialization, an important aspect of all NAFSIPs, and value additions are being promoted; however, regional trade is undeveloped and trade balance is negative in favor of developed countries. The livestock sector is also severely affected by the lack of marketing infrastructure and the generally poor communication network in the ASALs.

All the countries are in early stages of implementing NAPA's, but without detailed plans consistent with an overall adaptation strategy (Kissinger, et al., 2013). In addition, many of the projects have not been funded. Adaptation/mitigation options are generally for crops although the NAPAs and National Communications to UNFCCC indicate livestock as a major contributor to GHG emission., Although the climate smart agriculture paradigm was in operation before the development of the NAFSIPs,there are no specific CSA related policy instruments (FAO, 2010). The focus is also on immediate visible impacts and not on preparations for projected medium term impacts.

## Finances

With climate change as an emerging stress in food production systems, additional investment will be required to counter the effectson agriculture (Schmidhuber, et al., 2009). The NAPAs and other plans of action (in the case of Kenya) have shown potential impacts of the actions to increase resilience and mitigate climate change. The CSA framework provides opportunities for investments in the agricultural sector. In Eastern Africa, investments required for food production and improving the factors of production will be a proportion of the US $48 billion needed for Africa. Agricultural investments could also be obtained from mitigation opportunities that are about one-third of the total investment required in agriculture.

Across the countries, investment pillars integrate tenets of successful climate change adaptation frameworks, namely:

(i) Information for effective planning and forecasting
(ii) Infrastructure and management practices for climate proofing and resilience (flood mitigation; reservoirs, and irrigation channels)
(iii) Resilience enhancing measures for vulnerable groups
(iv) Institutions for disaster risk management, including early warning and response systems

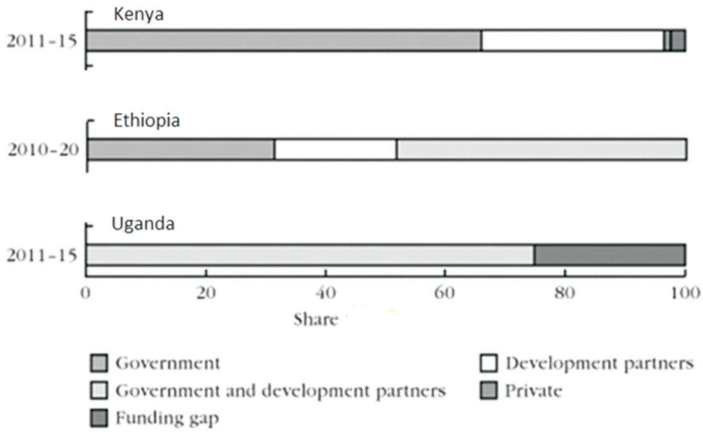



***Figure 6.1 Funding sources and gaps of CAADP national agricultural investments (Source: Benin et al., 2012)***

The three countries already depend on external funding sources and obtaining additional funding for CSA adoption may be difficult. Uganda finances about 35 percent of the budget, Kenya about 65 percent, while Ethiopia relies on a mix of government and development partners. External funding is therefore required to meet their respective budgets.

The NAFSIPs in all countries have large gaps in funding and are heavily reliant on donor funds. Both adaptation and mitigation actions for future agriculture strategies will lead to significant increases in the need for financing, with widening gaps if innovative financing methods are not found. For the study countries, improved production and productivity are important portions of the present investment plans. Uganda, for example, is spending a large percentage (43 percent) in research and capacity building, i.e., the generation of new technologies, research, improved extension service and information uptake, agro business development, strengthened farmer organizations and training. In Kenya and Ethiopia, a greater proportion of the budget allocated to increasing productivity and production is 68 and 57 percent, respectively. Value chains have a share of 6.7-11 percent across the region.

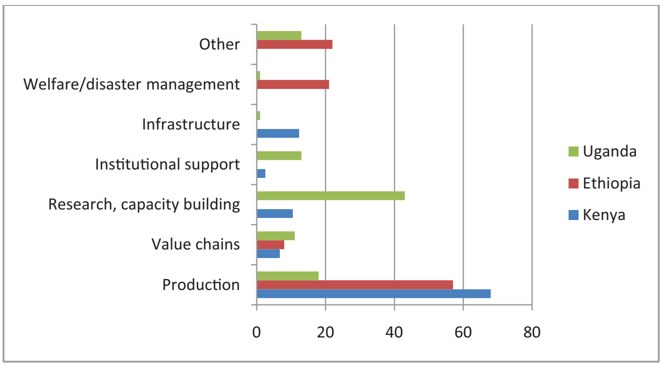



***Figure 6.2: Planned allocation of MTIP investment costs by expenditure type (% of total planned investment cost)***

All the study countries have ratified the CAADP process, have finalized NAIPs and applied for Global Agriculture and Food Security Program (GAFSP funding) (Table 6.1). The United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) and negotiations between governments are ideal for countries and Regional Economic Communities (RECs) to strengthen the climate and natural resources management components of their CAADP programmes in a systematic manner.

***Table 6.1 Role of NAIPs in accessing and application of GAFSP funds***

| Country | Year of accessing GAFSP funding | Amount obtained (US $) | Priority areas |
|---|---|---|---|
| Ethiopia | 2010 | 51.5m | Strengthen advisory services and improve small-scale infrastructure. |
| Uganda | 2013 | 27.6m | Support linking agriculture, nutrition, health and education. |

## 6.3 Climate Smart Agriculture Alliance as an Investment Opportunity

The NEPAD, through the CAADP, has launched an alliance of diverse partners such as CARE International, Catholic Relief Services (CRS), Concern Worldwide, Oxfam and World Vision, with the aim of reaching 25 million farming families through Climate-Smart Agriculture to become more resilient and food secure by 2025. The Alliance will

[3] Global Agriculture and Food Security Program (GAFSP), a multi-donor trust fund established in 2010 to improve food security in the world's poorest countries

develop a road map to stimulate the uptake of CSA practices, focusing on the vulnerable rural communities.

A major interestis how to coordinate and facilitate the scaling up of on-farm assistance, link to technological advances, and support a favourable policy environment for implementation of CSA for lasting transformation for farmers. Members will work collaboratively to design and implement programmes to maximize the efficiency, effectiveness and impact of investments. The Alliance expects to leverage existing CSA initiatives and the strengths and capacities of each Alliance member to deliver results at scale and drive policy reform. International non-governmental organisations (INGOs) and research activities across Africa will be aligned with existing national agricultural investment plans, for increasing coherence and coordination in the adoption of CSA strategies by the targeted farmers.

## 6.4 Investment Opportunities for Implementing CSA in Eastern Africa

At the governmental, regional and continental levels, food security is a major concern in the national poverty reduction strategy papers, agricultural development and investment plans of African countries and the agendas of international organizations. There is increasing awareness of the impacts of climate change on agriculture and the need to respond in appropriate ways by governments, regional and continental bodies, facilitated by FARA and through exchange of experiences on CSA between National Agriculture Research and Extension Systems (NARES) and the Consultative Group for International Agricultural Research (CGIAR) centres. The CGIAR's CRP7 programme aimed at reducing hunger, adapting to climate change and mitigating greenhouse gas emissions and improving livelihoods (CCAFS, 2011) is an opportunity for collaboration with national institutions. The CORAF policy of funding research and development projects jointly developed and implemented by at least 3 countries and the existence of broad agro-climatic regions, soil types and farming systems that cut across some countries, all facilitate scaling up and scaling out. Frameworksfor implementing NAFSIPs and PRSP, that are well set up and in line with government policies of decentralization of certain functions to district levels, could be exploited for CSA.

Existing knowledge and experience with CSA can guide governments and practitioners on CSA  example, the CCAFS Climate Smart Villages in Senegal and Burkina Faso or frameworks on climate change and gender mainstreaming FAO (2012). Additional opportunities include community level approaches for climate change adaptation developed by Environment and Development of Developing Countries (ENDA) (Ampomah and Devisscher, 2013), tools on integrating gender into CSA (BNRC, 2011) and Best Bet accounts.

It is well known that adequate and sustained financing is fundamental for CSA to be widely adopted by small-scale farmers. The CAADP framework provides guidance on sustainable financing and outlines the following:

- Develop, adapt and provide instruments and capacity development support to country and regional initiatives to engage and negotiate at global level for financing African Agriculture, from sources covering broader climate change objectives
- Target and facilitate direct engagement and accessto (i) bilateral and multilateral development aid (ii) direct foreign investments and local private financing and (iii) special instruments for public-private co-financing arrangements
- Provide instruments and related local capacity development in management,

budgeting, disbursement, accounting and auditing

The newly established Green Climate Fund (GCF) may shift the balance between mitigation and adaptation funding. In addition, the Global Environment Facility's (GEF) move towards combining mitigation and adaptation in the GEF-6CCM (FAO, 2013) will facilitate funding of CSA.

There are national farmers associations and regional farmers associations that play advocacy roles for farmers. At the community level, social capital in the form of Community and Farmer Based Organizations that alleviate labour shortage at critical periods in the farming calendar and provide support during natural disasters, is another opportunity for CSA. Many farmers (producers) are now aware of their vulnerability to the effects of climate change and investing in the following areas will influence the adoption of CSA:

### Incentive systems for implementing CSA

African governments (such as Malawi and Kenya) have often provided price support to farmers channeled through subsidies of inputs such as fertilizers. In Malawi, the subsidy resulted insignificant transformations in the agricultural sector through increased fertilizer adoption and improved maize production. Subsidies could be channeled as institutional support, pre-financing or polices that recognize and reward CSA practices or facilitate trade of CSA technologies.

### Introducing more secure land tenure

CSA practices such as agro-forestry, land management, fodder production and soil conservation require long term investments for success. Secure land tenure enables farmers to make these long term investments and increases their willingness to invest more money in the farm. There is the need to support the movement towards secure land tenure in all agricultural lands in the Eastern and Southern Africa (ESA) region to provide property rights to farmers who in turn, provide incentives for long term investment and engagements with ESA markets.

### Enabling Farming systems

Most farms in Eastern and Southern Africa comprise *ad hoc* complex mix of crops, livestock and trees that interact, often interdependently, such as maize stover providing forage for livestock (where the alternative is to burn the crop debris after harvest). Each of the farming systems have unique perspective for increasing productivity, adaptation and resilience, and mitigation of climate change that can be harnessed in a CSA framework.

### Overcoming the barriers of high opportunity costs to land

Many improved management practices provide benefits to farmers only after considerable periods of time. This can be prohibitive to poor households because investing in new practices requires labour and initial costs that must be made before the benefits areachieved. Pairing short-term practices with long-term ones may overcome some of the timing constraints. Payments for carbon sequestration may be an appropriate way of supporting the time lag between investing in climate-smart practices and obtaining the environmental and economic benefits. Currently, only Plan Vivo provides activity-based ex-ante payments for terrestrial carbon sequestration. Other financial instruments, such as micro-credits or index insurances, could provide the necessary funds or minimize risks to overcome these investment gaps.

## Providing an enabling legal and political environment

One of the core values of good governance is democracy. Democracy and its rules constitute the political and ethical guides that organize the relations between civil society and state. The rules of democracy include consensus, controlled power, accountability, legality, and access to information, among others. All these rules are aimed at generating a space of trust in the relationship of social and political actors, including those in agricultural development.

## Improved market and information access

Improved market and information access can be achieved through improving relevant infrastructure. The widespread availability and accessibility of modern information technology such as internet services, social media, mobile phones and radios in urban and rural areas is a major opportunity.

# 7. Key Drivers for CSA Adoption

## 7.1 Drivers for Promoting CSA in Eastern Africa Region

Promoting CSA in Africa requires that the threshold levels of incentive systems are developed and provided to farmers. The diffusion of CSA innovations is a socio-cultural process that can be promoted with support from policies and institutions aimed at developing sustainable change in a community. With a good environment, spontaneous spread of innovations occurs almost exclusively through farmer-to-farmer information exchange (Liniger and Critchley, 2007). The starting point for promoting CSA would require that farmers, researchers and policy makers have the same understanding of objectives and strategies for improving agricultural productivity.

Adaptation and mitigation play a critical role in the long term productivity of agricultural land. Communication, farmer training and capacity building at all levels of production is important in creating awareness about climate change in developing countries where climate change is still not well understood (Pelham, 2009). Farmers have difficulties in differentiating between impacts arising from climate change and problems caused by local environmental degradation (Mutimba et al., 2010). At the Kenya Agricultural and Livestock Research Organisation (KARLO) participatory rural appraisal meeting involving climate change experts, it was noted that across the eastern Africa region, all problems afflicting farmers that are related to decreasing crop yields are blamed on the climate.

The main drivers for promoting CSA in the region can be summarized as:

i) Policy environment and political will
ii) Funding and investment financing
iii) Institutions and human capital required to implement CSA
iv) Availability of high yielding CSA technologies and innovations continuously refined and adapted through R&D

Political will is critical in ensuring that CSA is mainstreamed in all government programs. Promoting CSA requires building farmers' capacity (social capital, human capital, assets and infrastructure including markets) and improving market access. Using data from Ethiopian households, Temesgen et al., (2008) noted that a number of factors such as age of the household head, wealth, information on climate change, social capital, and agro-ecological settings influence farmers' perceptions about climate change and, hence, adaptation. Across the region, studies have shown that gender, age of farmer, years of farming experience, household size, years of education, access to credit facilities, access to extension services, off-farm income generating activities are among the significant determinants of adopting climate change adaptation measures (Acquah-de Graft and Onumah, 2011; Deressa et al., 2008; Fosu-Mensah, et al., 2010; Kurukulasuriya and Mendelson, 2006; Mandleni and Anim, 2011; Mets et al., 2009). Capacity building which influences farmer training will therefore facilitate farmers in adopting CSA practices.

Socio-economic characteristics vary across eastern Africa; with many farmers about 55 years of age or over, mainly illiterate, and women being the most disadvantaged. African farmers work under harsh biophysical conditions, compounded by climate change, and face a myriad of problems at the farm, community and national levels. Agricultural productivity is, therefore, low. These are compelling arguments for governments and the international community to invest in climate smart agriculture. It is also important to assess the impacts of various CSA technologies on gender roles and equity.

CSA requires changes in farming households' strategies for producing food and fiber. Without appropriate institutional and policy structures in place, CSA innovations may seem overwhelming to smallholders. In the region, there are a wide range of institutions that support farmers in training, linkages with markets and in carrying out the diverse activities on the farm. These institutions play a critical role in relaying accurate and timely information, building farmers financial and production capacity, and providing a wide range of other support to farmers. Some of the notable farmer institutions include farmer cooperatives, international NGOs, women groups associations, research and governance.

Across Eastern Africa, lack of tenure security and limited property rights may hinder the adoption of CSA systems that involve soil and land management such as retention of carbon in forested and irrigated land or technologies that require long-term investment. Data collected showed that in Eastern Africa region, less than 30 percent of the households had secure land tenure. Comparing the security of land tenure in different farming systems, pastoral communities were the least secure. Insecure land tenure is a major hindrance to the adoption of CSA that limits the farmer's capacity to make long term investment decisions. Communal land tenure systems are more common in the arid and semi-arid AEZ. Table 7.1 shows the influence of the various variables on the adoption of CSA.

From the the sample countries, there exists opportunities for interventions which promote CSAs through addressing the socio-economic and structural constraints. Although educational levels of African farmers are low, (Table 7.2), there are opportunities for effective flow of CSA information through highly skilled extension staff. Simple information packages targeting low literacy farmers could also break the barriers to adoption of CSA.

***Table 7.1: Impact of different variables in adoption of CSA (Direction of influence)***

| Variable (Drivers) | Impacts ] | Comments on the direction of influence |
|---|---|---|
| Policy and institutional arrangement | +/- | Depending on which policies and institutions are in place, CSA can be promoted or dampened |
| Subsidy (targeting CSA) | + | Provide a bridge between the time of investment and time of reaping the benefits |
| Reduces the cost of investment | | |
| Research | +/- or neutral | CSA specific research could influence CSA<br>Research that is not fully planned and targeted may have negative or neutral impact |
| Government support of CSA (political good will) | + | Government is the main source of trust , financial and other forms of support for adoption of CSA |
| External funding on CSA | + | Means additional resource for designing and implementing CSA |
| Socio-economic characteristics | | |
| Gender of farmers | +/- | Gender roles and preferences influence which technologies may be adopted |
| Without mainstreaming gender, CSA cannot achieve its potential | | |
| Household wealth | + | Wealth influences the amount of money households can invest in CSA |
| Household Labor force | +/- | CSA technologies can either be labor saving, labor using or neutral. |
| Farmer extension supportand general human capital | + | Technical advice to farmers simplifies complexity is some technologies and increases technology adoption |

**Source:**FARA Field survey (2014)


*Table 7.2: Summary of factors that promote/hinder CSA*

| Variable | Influence |
|---|---|
| Socio-economic variable particularly the economic resources | Greater economic resources increase adaptive capacity of farmers<br>Lack of financial resources limits capacity to adopt new technologies |
| Technology | Lack of technology limits range of potential CSA options that farmers can choose from |
| Information and skills | Lack of informed, skilled and trained personnel (especially extension staff) leads to little promotion of CSA in the day to day programmes for agricultural development.<br>Lack of skills by the farming communities reduces their adaptive capacity |
| Infrastructure | Greater variety of infrastructure can enhance adoption of CSA. These include communication and market infrastructure. |
| Institutions | Well-developed social institutions help to increase flow of information, technologies and farmer support for promotion of CSA<br>Policies and regulations may constrain or enhance CSA |
| Equity | Equitable distribution of resources increases adoption of technologies such as property right and access to land in an equitable manner. |

## 7.2 Challenges/Constraints in Implementing CSA

### Land tenure systems

Unclear land tenure may lead to difficulties in establishing benefit distribution mechanisms for payments for ecosystem services (Runsten and Tapio-Bistrom, 2011). There is the need to address the land tenure issues to ensure that women's rights to land and long term investments inhouseholds are recognized and enforced. In all countries in Eastern Africa, men often control access to land through customary tenure, and, as a result, are often considered the main decision-makers in terms of crop management, investment options and other key decisions, including long term investments. Implementing CSA programmes that incorporate long term investments requires commitment and 'buy in'. On the other hand, women have greater authority over food production and may supply up to 80 percent of the labor required in the household to produce food. Women are also more likely to interact well with extension staff and other agencies that promote CSA, as compared to their male counterparts.

### Market failure resulting from poor access to information and markets

The potential of CSA depends on the capacity to: convey market information; coordinate production and marketing, define and enforce property rights; mobilize farmers to participate in markets, and enhance the competitiveness of agro-enterprises (FAO, 2012). Without proper markets, price mechanisms may not allocate resources well, which may lead to distortions in Implementing CSA.

### Poor business development services

Farmers in the region are risk averse and prefer not to use credit for farming activities. The reason could be linked to a poor business environment that is unable to respond to the unique needs of farmers and develop a suitable financial product. – This includes financing, market information, input supply, extension, collection and process, storage and transport. On the other hand, the product market is highly volatile with unpredictable prices and farmers are in a non-structured marketing system. There is a need to improve the overall agribusiness environment through simple, transparent regulations, tax structures and finance regulations in order to attract more investment on CSA.

### Institutions/socioeconomics

There are several human, social, and economic challenges at the community level. Traditional systems of inheritance and ownership of land have consequences for the adoption of investment technologies such as tree planting that will support soil and water structures for several years. In areas where the inheritance of land is patrilineal, decisions are made by the head of the families on allocation of land for annual cropping, so women and foreigners may have access to land although women provide a very large part of the agricultural labour force. Tenants (foreigners) are generally excluded from planting perennial crops or trees because tree planting indicates long term interest and investment in the land. Other challenges are high levels of poverty and illiteracy, poor health status in rural areas, high investment costs of CSA, and inadequate access to land, labour, and credit for agriculture, especially for women. Rural to urban migration by youth contributes to labour shortage at critical periods. This impacts on theadoption of soil and water technology such as stone bunds and zai that are high in initial labour demands.

## Research/Technology Transfer/Finance

Research on how to mitigate the impacts of climate change and variability on agricultural productivity is still very limited (Antai, et al., 2012). There is inadequate knowledge of how technical CSA practices will perform in specific locations; appropriateness and profitability of CSA technologies; how trade will be affected by climate change; how crop yields will be impacted based on GCMs; risk management and insurance in different countries; and landscape approaches in achieving CSA (for example, numerous tiny farm holdings for crop farming are limiting factors). In addition, there is limited or no involvement of policy makers in the research process, as well as ineffective forms of communicating research results to policy makers and end users. The initial investments for CSA technologies are generally high, while the benefits may not be immediate. Governments are constrained to provide the required funding, even for NAFSIPs, PRSPs and institutions responsible for data collection and research. As most funding required for key programmes is from external sources, the incorporation of CSA would require additional funds.

## Policy, Plans and Programmes

Mitigation benefits associated with adaptation options are not recognized in national agricultural development and investment plans. Excluding the NAPAs and Communications to UNFCCC, climate adaptation programmes are usually separate from agricultural development policies, plans and programmes. Policy contradictions may occur because of failure to recognize and manage trade-offs when CSA is not aligned with agricultural policies. Other challenges are that livestock policies are separate from crop policies; there is lack of political will and reluctance to invest in perceived medium and long term uncertainties; and the research to policy- making linkage is often linear. The importance of research, as part of overall agricultural policy, is still not adequately recognized. IMF/World Bank policies discourage subsidies in the agricultural sector, so governments have resorted to incentive strategies such as food for work and reduced tax duties on imported agricultural inputs. How effective these are is uncertain. The following are broad challenges that are common to the countries surveyed and CSA practices (Table 7.3).

*Table 7.3: Summary of challengesof adopting CSA and possible solutions*

| Main barriers | Action lines for addressing the barriers |
|---|---|
| Diverse interests as expressed in terms of policies, strategies, investment priorities and organisational objectives. | Establish hierarchy of outcomes and record each partner's contribution |
| Managing complexity, where all partners want their interests accommodated (in the form of indicators) | Carefully select indicators – compromise to avoid unmanageable complexity. Understand which areas are critical at a particular time and putemphasis on these to be able to generate the messages needed. |
| Political interference affecting the credibility and validity of the data | Need to understand the political imperative behind data sources and management authority. Data quality control and protocols generated by the Alliance to be shared widely to validate sources and data quality. |
| Capacity variation–different skills and capacities across nations and organizations. | Undertake a capacity needs assessment in participating CSA organizations. Develop activities to fulfill these gaps (training, recruitment, build infrastructure, etc.). |
| Different M&E approaches language and terminology. | Develop appropriate Alliance definitions/ terminology and be consistent; Undertake a harmonization approach; Explain clearly to enable organizations map exclusive terminologies. |
| Language–mostly a challenge for learning systems at a farmer level. | This will be complex but can be handled atlocal levels. National and regional levels are usually in English and French. |
| Counting the 25 million farmers will be challenging due to:<br>- definition of CSA adoption/ partial adoption<br>- new vs. old farmers adopting CSA<br>Organization of ministries – ministerial | PMF and Indicator definition activities will inform this. |
| collaboration | Engage high level from the beginning |
| Poor and unstructured markets | Contracts, market and value chains |
| Risk (production, enterprise) | Insurance and finanacial buffers |

**Source:** FARA PRA Survey (2014)

# 8. Creating Enabling Environments for Adoption of CSA

## Encouraging Farmers to Adopt Climate-Smart Practices

The priority for small-scale farmers in Africa is to minimize the impacts of climate change and increase their production. Mitigation is often a positive non-intended outcome unless farmers are provided incentives, for instance, under projects such as Vi Agro. Where appropriate, policymakers should encourage the operation of such projects and farmers to reap the benefits of adopting CSA.

Under the Vi Agro Project, conservation agriculture that involves strategies such as minimum tillage, retention of organic matter, and crop rotation, help farmers increase crop yields, cope with climatic variability and reduce carbon emissions. Agroforestry can sequester carbon, improve soil fertility, reduce soil erosion, provide alternate pasture and raise smallholders' incomes. Farmers can be encouraged to adopt these technologies through education about the reduced climate change risks associated with the adoption of climate-smart practices.

## Adopting a Multi-Sectoral Approach to Policy Making

Increasing the adoption of CSA practices requires action and facilitation by a wide range of actors at different levels of hierarchy in the resource and power base. Typically, a successful CSA policy should encourage resource allocation and action by a wide range of government ministries, including those with responsibility for agriculture, rural development, research, environment, trade, education and transport.

## Creating the Financial Incentives for Climate-Smart Agriculture

Successful CSA strategies will require investment in infrastructure that support smallholder farmers in understanding climate change, developing and refining strategies and evaluating CSA options. Some researchers have recommended the establishment of transition funds to be used to compensate farmers during the periods between the establishment of CSA structures and benefits, such as Agroforestry practices.

Farmers can also benefit from additional funds through the Payment for Environmental Services (PES) schemes. The development of PES programmes is beyond farmers' capacity. As such, a special fund could enable farmers benefit from such schemes leading to higher adoption of CSA practices.

## Developing Effective Research

The present state of research in Africa, especially in the National Agriculture Research Institutes (NARIs) and Universities is characterized by poorly maintained and overburdened facilities, often with few female staff. There is a limited data sharing system and research learning platforms with few CSA learning areas. The research agenda for research institutions or scientists is often informed by a wide range of factors, including the provider of the research funds. Developing a research scheme with dedicated funds for CSA research will ensure that CSA practices are continually improved and adapted to changing climate and farmer circumstances.

## Mainstreaming CSA at the National and International Levels

CSA will gain the necessary attention if it is mainstreamed into national agendas and strategies and in international negotiations forums. There is the need to lobby governments to consider CSA as an important intervention measure to improve poverty and incomes, food and nutrition security.

## Gender in Agricultural Development and Climate Smart Agriculture

Women's rights to property vary within and between countries in sub Saharan Africa. A gender-sensitive approach is crucial to achieving CSA. The roles, responsibilities and capabilities of men and women need to be well understood to ensure that both men and women have access to and benefit from CSA practices and policies. Some of the gender constraints that need to be addressed include land tenure systems and availability of funds to invest in better technologies. Women and men respond differently to climate change and in taking advantage of opportunities presented by CSA. Through understanding how climate change impact men and women differently, programmes and policies promoting adaptation to climate variability and change can be designed to ensure that impacts are addressed in gender-equitable ways to increase the adoption of CSA.

# 9. Conclusion And Recommendations

This section provides concluding remarks and recommendations based on issues raised in the survey.

## 9.1. Successful CSA practices for scaling up and out

There are a range of appropriate technologies recommended for different agro-ecological zones of eastern Africa. These technologies have the capacity to improve food production, enable farmers to maintain their food production with climate variability and change, and contribute to mitigation through reducing/avoiding GHG emissions. CSA provides an opportunity for agriculture to contribute to the investments required to improve production through participation in carbon markets.

**Recommendation:**

Investments should target the promotion of CSA technologies instead of continued generation of additional technologies.

Technologies need to be evaluated to assess suitability to small-holder farming circumstances and characteristics (socio-economic conditions) and consequences on long-term farm productivity, efficiency in resource use and improvement of productivity of factors of production.

## 9.2 Policies that promote Climate Smart Agriculture

There are no specific policies promoting CSA at national, sub-regional, and regional levels. The National Food Security and Investment Plans all have elements of CSA but do not explicitly promote it. No proven successful national policy model for inter-sectoral collaboration and leveraging of finance was identified in the study, although policy and strategy documents mention inter-ministerial committees and decentralization of government functions to district level.

**Recommendation:**

FARA and ASARECA should play a leading role in negotiations towards the institutionalization of CSA by establishing institutions that promote CSA rather than relying on general food security and climate change related policies. This will include funding of CSA related activities through the establishment of agricultural carbon markets at the national or regional levels.

i) Secure land tenure systems provide incentives for long-term investments such as agro-forestry, soil and water management. Land ownership reforms are therefore required, especially among the pastoral communities in the region.
ii) The region should develop a regional CSA information framework for lesson sharing

## 9.3 Existing gaps and investment opportunities

There are significant gaps in capacity, technical knowledge and financing. Studies on the impacts of climate change on livestock are inadequate, with few livestock models and none on effects of heat or water stress. Also lacking is the integration of adaptation and mitigation into policy and practice, and mainstreaming of climate change issues into agricultural. There are financial gaps because governments are unable to fund their NAFSIPs.

**Recommendations:**

CSA practitioners (researchers, development workers and organizations) should: consider gaps in crop and livestock research and development as priority areas; identify types of support required most by stakeholders; and capacity building efforts should include workshops and study tours for national research, extension staff and policy makers.

i) Farmer-based participatory experimentation and complementation of indigenous knowledge with scientific facts should be adopted.

ii) Gender should be streamlined in CSA programmes

iii) AU -NEPAD should strengthen its support to governments to enable them access funds from existing and new sources under different funding instruments.

iv) Communities should be supported to develop CSA communities of practice for channeling information and training of farmers.

## 9.4 Variables / drivers that promote / hinder the adoption of CSA

The drivers for scaling up CSA include technology dissemination; communication and information; capacity building in CSA; social capital; appropriateness and profitability of CSA technologies; access to credit, inputs and markets; gender equity; strong government support for both policy and scaling up frameworks; overall national economic environment, finances from multiple sources and incentives for farmers.

Broad qualitative and quantitative indicators of agricultural productivity, human development and adaptive capacity of farmers are low. These indicators, refined in a participatory manner with stakeholders at the farm, community and national levels, should be used to monitor and evaluate CSA interventions.

**Recommendation:**

There is the need to have a coordinated agenda towards CSA across eastern Africa emphasizing on capacity building of farmers, mobilizing finances, achieving political will, and strengthening institutions, research and development capacities.

## 9.5 Challenges and opportunities to scale up and out CSA

CSA in its true comprehensive form is not yet apparent for governments and farmers; rather elements are being implemented across Africa. Many of the technologies are designed first to increase production rather than protect the natural resource base.

**Recommendation:**

The following practices need to be upscaled and outscaled:

- Improved drought tolerant crop varieties and livestock breeds (mainly adaptation measures)
- Integrated soil fertility management (including microdosing)
- Water harvesting (including zai pits)
- Cross slope barriers (stone bunds / vegetative barriers)
- Agroforestry (including parklands and assisted natural regeneration)
- Lowland rice cropping

Besides the technological options, climate risk management techniques such as seasonal weather forecasting, index-based insurance and safety nets should be promoted. The community-based participatory climate smart village approach involving climate risk management should also be supported.

Currently, positive responses to CSA have been reported for important food and cash crops such as millet, sorghum, groundnut, rice, maize for mainly semiarid/sub-humid zones; and maize, rice and groundnut in mainly sub-humid/ Highland zones.

Drought tolerant crop species and varieties should replace less drought tolerant ones in areas where rainfall is predicted to decline and vice-versa where rainfall may increase. It is desirable to develop varieties with some tolerance to salinity, flooding, drought and responsive to integrated soil fertility management.

Little information is available on the response of livestock to CSA. Cattle are mostly important in the semi arid zones, and small ruminants and poultry in all zones. Livestock breeds that are relatively heat and drought tolerant should be promoted in all agro-climatic zones.

Information sharing across regions provides a quicker approach for promoting technologies. More attention needs to be given to improving productivity and promoting breeds of small ruminants (sheep and goats) that can cope with harsh environmental conditions. Local breeds of livestock are relatively better adapted to heat and drought than exotic breeds. Artificial insemination systems that can combine hardiness with productivity in breeds of cattle and small ruminants should be strengthened.

## 9.6. Gender Considerations

Women in rural communities of the three countries are particularly vulnerable to climate change due to various disadvantages. Gender is being taken into account in developing responses to climate change, but the efforts are not extensive enough.

**Recommendation:**

Mainstream gender issues into agricultural development and climate change policies and programmes.

CSA technologies should be assessed for their potential impacts on gender equity and promote women's access to agricultural extension services and training, credit, and factors of production.

## 9.7 Conclusion

In conclusion, FARA should provide a programme for linking existing platforms such as the following, for promoting CSA in the region:

- African conservation tillage network
- Platform for African-European Partnership on Agricultural Research (PAEPARD)
- European research/education network
- Pan African Association of Farmer Organizations (PAFFO), and its constituent Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)
- African Policy Analysis Network (FANRPAN)
- Constituent organisations of the European Alliance on Agricultural Knowledge for Development (AGRINATURA) – French Agricultural Research Centre for International Development (CIRAD), Istituto Agronomico per l'Oltremare (IAO) and Natural Resources Institute (NRI)
- Africa-Caribbean-Pacific Liaison Committee for the promotion of ACP horticultural exports (COLEACP).

This can be achieved through forming a community of practice, including champions and strategic partners who have embraced CSA, to catalyze the adoption of CSA. CSA alliance need to establish an M&E framework should be established to track the progress of nations, institutions and farmers towards climate smart agriculture.

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# ANNEXES

## ANNEX 1: List of Contacted Persons

| | |
|---|---|
| Benson Mwaura | University of Nairobi |
| Caroline Mwongera | CIAT, Nairobi |
| Daniel Omondi | KCCS |
| Eddah Kaguthi | KARLO, Kenya |
| Elizabeth Okwousa | KARLO, Kenya |
| Eric Eboh | Agricultural Policy Research Network, Nigeria |
| Francis Mwaura | Uganda Policy Research Organization |
| Jane Wamuongo | KARLO, Kenya |
| Keziah Ndungo | KARLO, Kenya |
| Mary Kifuko | KARLO, Kenya |
| Michael Okoti | KARLO, Kenya |
| Mr Nathan Phiri, | ARI, Zambia |
| Rebecca Mbinge | University of Eldoret |

# ANNEX 2: Terms of Reference

## OBJECTIVES OF THE ASSIGNMENT

The main purpose of the survey is to identify and document the best bet practices of climate smart agriculture that can be shared and scaled up in other countries in order to mitigate the effects of climate change on food security and livelihoods

Specifically, the survey will:

1. Identify, document and collect baseline data and information on successful climate-smart agricultural practices for scaling up and outscaling
2. Document and collect data and information on variables that promote climate smart agriculture
3. Identify existing gaps and investment opportunities where CSA can intervene within the CAADP framework
4. Determine the drivers, challenges or constraints that may facilitate or hinder scaling up and out of CSA practices in Africa
5. Ascertain the priority crops and livestock that are suitable for CSA practices across different agro-ecologies in Africa

### OUTPUT AND DELIVERABLES

The consultant is expected to deliver the following outputs:

1. A detailed work plan for accomplishing the assignment giving a description of the methods to be used
2. A draft report that includes the following for review by the FARA Secretariat staff
    - A table of contents
    - An Executive Summary
    - Introduction
    - Methodology
    - Outcome of Baseline Surveys
    - Conclusions and Recommendations
    - References
    - Annexes
3. A detailed final report that incorporates comments/inputs from stakeholders to FARA Secretariat

# About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organization responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.

FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).

**FARA's vision:** Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises.

**FARA's mission:** Creation of broad-based improvements in agricultural productivity, competitiveness and markets by continental-level strengthening of capacity for agricultural innovation.

**FARA's value proposition:** Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation.

FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is, in turn, designed to support the realisation of the CAADP vision. FARA's programme is organised around three strategic priorities, namely:

- Visioning Africa's agricultural transformation with foresight, strategic analysis and partnerships to enable Africa to determine the future of its agriculture, with proactive approaches to exploit opportunities in agribusiness, trade and markets, taking the best advantage of emerging sciences, technologies and risk mitigation and using the combined strengths of public and private stakeholders.
- Integrating capacities for change by making the different actors aware of each other's capacities and contributions, connecting institutions and matching capacity supply to demand to create consolidated, high-capacity and effective African agricultural innovation systems that can use relative institutional collaborative advantages to mutual benefit while also strengthening their own human and institutional capacities.
- Enabling environment for implementation, initially through evidence-based advocacy, communication and widespread stakeholder awareness and engagement and to generate enabling policies, and then ensure that they get the stakeholder support required for the sustainable implementation of programmes for African agricultural innovation

Key to this is the delivery of three important results, which respond to the strategic priorities expressed by FARA's clients. These are:

**Key Result 1:** Stakeholders empowered to determine how the sector should be transformed and undertake collective actions in a gender-sensitive manner

**Key Result 2:** Strengthened and integrated continental capacity that responds to stakeholder demands within the agricultural innovation system in a gender-sensitive manner

**Key Result 3:** Enabling environment for increased AR4D investment and implementation of agricultural innovation systems in a gender-sensitive manner

FARA's development partners are the African Development Bank (AfDB), the Canadian International Development Agency (CIDA)/ Department of Foreign Affairs, Trade and Development (DFATD), the Danish International Development Agency (DANIDA), the Department for International Development (DFID), the European Commission (EC), The Consultative Group in International Agricultural Research (CGIAR), the Governments of the Netherlands and Italy, the Norwegian Agency for Development Cooperation (NORAD), Australian Agency for International Development (AusAiD) and The World Bank.

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