State of Knowledge on CSA in Africa:
Synthesis of Regional Case Studies

FARA
Forum for Agricultural Research in Africa
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Synthesis of Regional Case Studies

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The findings, interpretations, and conclusions expressed in this report are those of the authors and do not necessarily reflect the views of the Executive Director of FARA or their staff.

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Acronyms and Abbreviations

ANACIM	Meteorological Agency, Senegal
APRNET	Agricultural Policy Research Network
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Programme
CARE	International Cooperative for Assistance and Relief Everywhere
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CC	Climate Change
CCAFS	Climate Change, Agriculture and Food Security Programme of the CGIAR
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	La recherché agronomique pour le développement
COMESA	Common Market for Eastern and Southern Africa
COMNAC	National Committee on Climate Change
CORAF	West and Central African Council for Agricultural Research and Development
CSA	Climate Smart Agriculture
CSC	Ecological Monitoring Centre
CSIRO	Commonwealth Scientific and Industrial Research Organization
ECOWAP	Economic Community of West African States Agricultural Policy
ECOWAS	Economic Community of West African States
ENDA	Energie Environnement Developpement
EU	European Union
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network

FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics Department
FARA	Forum for Agricultural Research in Africa
FMARD	Federal Ministry of Agriculture and Rural Development
GCM	General Circulation Model
GEF	Global Environment al Facility
GHG	Green House Gas
GOSL	Government of Sierra Leone
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INERA	Institute de l'Environnement et de Recherches Agricoles
IPCC	Intergovernmental Panel on Climate Change
ISRA	Institute de l'Environnement et de Recherches Agricoles
KARI	Kenyan Agricultural Research Institute
LGP	Length of Growing Period
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
NARES	National Agricultural Research and Extension Systems
NARF	National Agricultural Resilience Framework
NASRO	North African Sub-Regional Research Organization
NASPA-CCN	National Adaptation Strategy and Plan of Action on Climate Change in Nigeria
NEPAD	New Partnership for Africa's Development
NERICA	New Rice for Africa
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development Cooperation
NSESD	National Strategy for Economic and Social Development
PNIA	National Agricultural Investment Plan

PNSR	National Programme for Food Security
PRSP	Poverty Reduction Strategy Paper
RARC	Rokupr Agricultural Research Centre
SCADD	Strategy for Accelerated Growth and Sustainable Development
SCP	Smallholder Commercialization Programme
SDR	Strategy for Rural Development
SLARI	Sierra Leone Agricultural Research Institute
SLIEPA	Sierra Lone Import and Export Promotion Agency
SLM	Sustainable Land Management
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme

Acknowledgement

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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 emissions.

Although there are many research and analytical efforts to minimize the impact of climate change on agriculture and on 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 knowledge as it exists in all the four Sub Regions: Western Africa (Burkina, Senegal and Sierra Leone), Eastern Africa (Ethiopia, Kenya and Uganda), Central Africa (Cameroon, Democratic Republic of Congo and Nigeria), Southern Africa (Tanzania, Malawi and Zambia).

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

Executive Summary

Agriculture in Africa is highly vulnerable to climate change and urgent actions are needed to combat its impacts and maintain or improve food security and livelihoods. The adverse impacts of climate change and variability are a threat to the ecosystems and livelihoods of communities in Africa. Severe droughts, floods and extreme weather events are occurring with greater frequency and intensity in the region. The opportunity offered by Climate Smart Agriculture (CSA) gives the possibility of simultaneously raising productivity, enhancing resilience and mitigating carbon emissions. These three possibilities address existing challenges to agriculture in the African continent which include, the urgency of food insecurity, climate change, and related carbon emission. To effectively address these at the African level requires innovations, technologies and policy interventions that are knowledge-based. The Forum for Agricultural Research in Africa (FARA), with support from the Norwegian Agency for Development (NORAD) recognizing the need to promote CSA in Africa, carried out 12 case studies to determine the state of knowledge of CSA in these selected countires.

The primary purpose of the study was to identify and document the best practices of CSA that can be shared and scaled up and out in order to mitigate the effects of climate change on food security and livelihoods. The specific objectives were to:

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

Data collected from desk studies and rapid field surveys involved (i) key informants as experts in the field of climate change and CSA, and (ii) review of literature on the socio-economic characteristics of African farmers, food production systems, climate change adaptation and mitigation as well as policies. Twelve countries: Burkina Faso, Senegal, Sierra Leone; Ethiopia, Kenya Uganda, Nigeria Cameroon, Democratic Republic of Congo; Rwanda, Tanzania and Zambia were selected as study countries representing Africa's Agro-Ecological Zones (AEZ) and farming systems.

Following inception meetings at the FARA secretariat, Accra, in which the survey instruments were developed, desk studies was undertaken involving accessing literature on CSA from local and international sources. This included review of national policies, strategies, programmes and plans related to agricultural development and CSA in the twelve countries. The next step was a rapid field survey involving nationals (key informants) based in the selected countries to obtain and collate information/data from researchers, extension workers, farmers and policy makers. The key messages from the studies included:

- All the counties in the case studies are experiencing climate change, which is manifested as an increase in the frequency and intensity of climatic hazards such as droughts and floods. The available evidence indicates that annual average temperatures have increased over the past three decades and rainfall regimes are predicted to increase as well as decrease, over the next 30 years depending on GCM model used. The impacts of climate change on agriculture are varied depending on the type of predictive models used, crop varieties and the agro-ecological zone. Under climate change, agricultural systems will require technologies that will deliver improved production, full potential of varieties and breeds and better control of pests and diseases.

- Farmers in Sub-Sahara Africa in all the agro-climatic zones are generally poor, and mainly illiterate, operators of rain fed farming systems, cultivating small farms (<1- 5 hectares) with soils of low fertility, and producing very low crop yields. The adaptive capacity of African farmers is low as a consequence of their poor socio-economic circumstances, the harsh biophysical environments, low technology, as well as poor infrastructure that they have to contend with. Women form over 50% of the agricultural workforce while over 90% of households are headed by men. Access to agricultural credit and markets by both male and female farmers is a challenge and ownership of land by women is poor.

- Technologies need to be evaluated to determine 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. Research and development should improve productivity of present CSA technologies to mimic that of the green revolution. Research should be directed towards developing methods for quantifying carbon under different farming systems and CSA technologies to allow farmers to demonstrate their contribution in mitigating climate change and to enable them to participate in carbon markets.

- Scaling up and out of CSA Best Bets practices can be achieved through provision of incentives for farmers; alignment of CSA with appropriate economic, health, social, energy, and other relevant policies; as well as mainstreaming of CSA into NAFSIPs. Investments are required to develop CSA technologies and related research. Technological options should be based on the principles of sustainable land management; risk management approaches such as seasonal weather forecasts, index-based crop insurance and safety nets; and a participatory climate smart village approach that cushion farmers from the risks and uncertainties of investment in long-term agricultural projects and to make upfront payments on CSA investments.

- The following practices need to be up-scaled and out-scaled: improved high yielding and short duration crop varieties tolerant to stresses such as drought, floods, salinity and disease. Improved varieties of important staples such as cassava, maize, sorghum, millet, and rice have been developed by collaboration between national and international research organizations, and are available to farmers; 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. Livestock systems require improved technologies, improved livestock and forage production and, improved genetic potential of livestock breeds and control of animal diseases.

- Women in rural farming communities of all countries in the baseline study are particularly vulnerable to climate change. Women form the majority of workforce in agriculture though they have some limitation in owning the land. Gender considerations must be taken into consideration in all aspects of scaling up and out of CSA. For gender to be properly incorporated into the responses to climate change, the various gender roles played by women and men in farming should be understood and special attention should be given to the empowerment of women to take care of their strategic interests.

Several gaps concerning the development and implementation of CSA are identified in the areas of production and commercialization, these include; scale of implementation of CSA (plot, farm, and landscape); institutions; integration of adaptation and mitigation; knowledge and scientific capacity to improve adaptation/mitigation response; gender; policy and financing. Much more information is available for the crops subsector compared to the livestock subsector.

The underlying drivers of scaling up and out of climate smart agriculture are appropriateness and profitability of CSA technologies, approach to technology dissemination, communication and information between stakeholders, capacity building of stakeholders, access to land, credit, inputs and markets by farmers, government policy support, gender equity, government policy and financial support to farmers. Improved high yielding varieties of millet, sorghum, maize, groundnut, cassava and rice all tolerant to stresses such as drought, floods, salinity and diseases are needed for CSA. Tree crops (cocoa, coffee) as components of agroforestry systems are also suitable for CSA. Drought and heat tolerant cattle and small ruminants (sheep and goats) swine and poultry all play a part in CSA.

It can be inferred from the findings of the studies, that opportunities exist to promote CSA in Africa through addressing the socio-economic and structural constraints facing African farmers. Interventions aimed at reducing or eliminating the gaps in the priority areas identified by the studies should be undertaken by the appropriate stakeholders, all of whom should be made to understand the drivers of scaling up and out and how they may be manipulated for successful outcomes. The key to CSA is to ensure effective flow of CSA information through highly skilled extension staff with targeted information packages. Investments are required to develop CSA technologies and related research to support the technologies. In addition to technological options, climate risk management techniques such as seasonal weather forecasting, index-based insurance and safety nets should be promoted.

There is a need for the coordination of efforts towards CSA through sharing lessons and linking farmers to markets. Governments will play a critical role in adoption of CSA by influencing policies and institutions that are key drivers to promoting CSA. Coordination is required to lobby African governments to achieve buy-in as a major step towards widespread promotion of CSA in Africa. National, regional and international partners (NGOs, UN Agencies, CGIAR, AU-NEPAD, ECOWAS, FARA, CORAF/WECARD, and donor agencies) should commit funds for successful research and development of CSA, where governments cannot fully fund national budgets. Consistent with her mandate, FARA should lead the process to sensitize governments to have CSA-responsive policies and respond to regional and continental policies and agreements.

1. Introduction

1.1 Background

Africa is highly vulnerable to climate change because of social, economic, and environmental factors. Climate change will interact with non-climate drivers to amplify vulnerability of agricultural systems particularly in the semi-arid areas of Africa (Niang, *et al.,* 2014).The evidence of climate change such as rising temperature and changes in precipitation is clearly seen in recent years with impacts already affecting agriculture, ecosystems, biodiversity and people.

Africa depends heavily on rain-fed agriculture making rural livelihoods and food security highly vulnerable to climate variability such as shifts in growing season conditions. Unless serious action is taken, Africa will continue to be food insecure and poor. The region needs to develop and implement sustainable agro-ecological food and agricultural systems that improve soil fertility, ensure efficient land and water use that are resilient to climate change and protect biodiversity. Africa's initial response to climate change was mainly in terms of promoting adaptation measures (Rhodes, et al., 2014). However, more innovative ways on how land, water, soil nutrients and genetic resources could be managed are needed to address the challenges of meeting food security in the face of climate change, population growth and other stresses while preserving the natural resource base for agriculture.

The need to seriously respond to climate change has been recognized at the continental and regional levels (ECOWAS, 2009a, 2009b). One of the strategies 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. Implied 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 three key pillars of CSA are the enhancement of productivity, adaptation and mitigation in the agriculture sector. In addition, good coordination across the agricultural subsectors of crops and livestock as well as related sectors such as forestry, water, energy and infrastructure is required so as to capitalize on potential synergies, reduce trade-offs and optimize the use of natural resources and ecosystem services (FAO, 2010; FAO, 2013).

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

- Visioning Africa's agricultural transformation through foresight, strategic analysis and partnerships to enable African agricultural stakeholders determine how agriculture should develop and plan for it based on evidence and the combined strength of all stakeholders;
- Integrating capacities for change by making the different actors aware of each other's capacities and contributions, and helping them to exploit their relative comparative advantages for mutual benefit while also strengthening their own human and institutional capacities;
- Creating an enabling environment for implementation through advocacy and communication to ensure that African policy makers get the evidence they need to generate enabling policies and ensure that they get the stakeholder support required for their implementation.

Delivery of the results for these three strategic priorities hinges on strengthening the capacities of African actors in agricultural knowledge and innovation systems, including CSA, to be more effective and efficient in supporting the CAADP country process.

There is currently no comprehensive documentation and analysis of information showing the successful practice of CSA for the major agro-ecological zones of Africa and policies to stimulate sustained CSA practice and adoption .With support from the Norwegian Agency for Development Cooperation (NORAD), the Forum for Agricultural Research in Africa (FARA) Secretariat in collaboration with the SRO (CORAF/WECARD) undertook surveys in the semi-arid, sub-humid and humid zones of West Africa to generate data and information on CSA issues that could be used to support evidence-based CSA policy and programme design, as well as performance monitoring. Such surveys are intended to provide information on the current situation and trends needed to complement strategic policy studies; support capacity to design evidence-based CSA policies; provide circumstance-specific political economy data; and information on CSA that will be available for the design of gender-sensitive policy options on climate change, environmental sustainability and food security to support the development of guidelines, systems and methodologies for integrating the research, extension and education aspects of CSA into the CAADP country investment plans.

1.2 Objectives

The primary purpose of the study (Appendix 1: Terms of Reference) is to identify and document the Best Practices of climate smart agriculture(in the crops and livestock sub sectors) that can be shared and scaled up and out in order to mitigate the effects of climate change on food security and livelihoods. The specific objectives are to:

- Identify, document and collect data and information on successful climate-smart agricultural practices for scaling up/out;
- Document and collect data and information on policies that promote climate-smart agriculture;

- Identify existing gaps and investment opportunities where CSA can intervene within the CAADP framework;

- Determine the drivers, challenges or opportunities that may facilitate or hinder scaling up and out CSA practices in West Africa; and

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

- It is expected that this synthesis and the four regional reports will serve as a valuable baseline that will be used to access progress in the adoption of CSA as well as provide entry points for governments to remove barriers that hinder the adoption of CSA.

Plate 1.1 Maize and Cowpea intercropping

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 common understanding of the terms of reference and to develop tools for collecting data for this report.

2.2 Sources of Data and Data Collection

Primary and secondary data were used in the survey which consisted of the following stages:

1. **Literature review:** Desk study involving accessing information from national and international sources and reviewing 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.

2. **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 studied countries. This involved obtaining information from nationals in selected countries and field visits.

2.3 Study Area

The study area included the major Agro-ecological zones of Africa (Figure 2.1) as established from existing literature distributed over West, Central, Eastern and Southern Africa. Consequently the main agro-ecological zones of interest for each region were the semi-arid, sub-humid and humid rainforest of West Africa, the humid rainforest of Central Africa, and sub-humid and Highland semi-arid of East Africa, and the arid areas of southern Africa. These were considered a fair characterization of the agro-ecological zones of the continent to obtain baseline information on the state of knowledge on CSA.

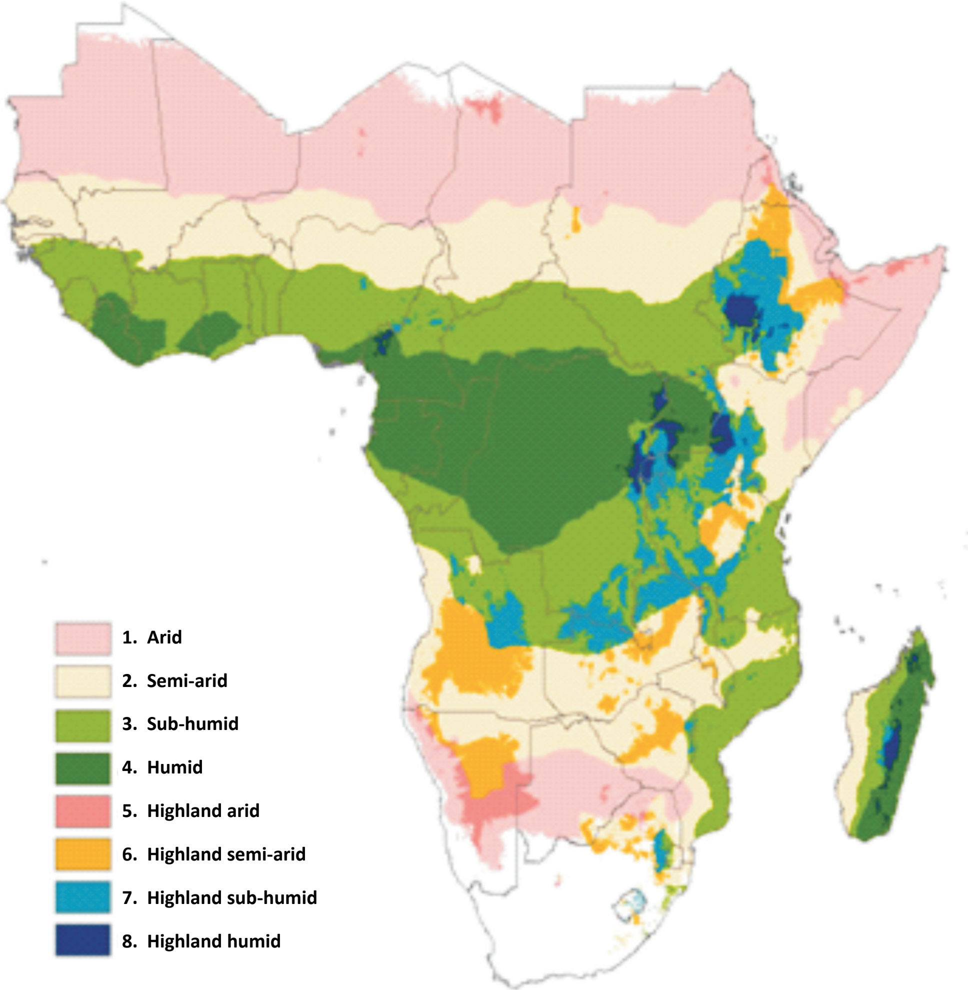


Figure 2.1 Agro-Ecological Zones of Africa

Source: http://www.ipipotash.org/fr/eifc-image/2012/32/6/map2

2.4 Sampling Procedure

The sampling was purposive. It involved (i) identification of the major AEZ and farming systems of Africa (Table 2.1 and Table 2.2), (ii) selection of countries representative of these AEZ and farming systems (iii) identification of key informants based on their experience and knowledge of CSA. The following countries were selected – Burkina Faso, Cameroon, Democratic Republic of the Congo, Ethiopia, Kenya, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, and Zambia. The basis for selection of these countries was to reflect the major AEZ and farming systems of Africa. Burkina Faso, Senegal and parts of Zambia fall within the semi-arid and sub-humid agro climatic zones while DR Congo, Cameroon, Nigeria, Rwanda, Sierra Leone are in the humid and sub-humid agro-ecological zones. The other countries had more than one AEZ.

Table 2.1The agro-ecological zones of the selected countries

SROs/ FARA Geo-ecological zones	Major agro-ecological zones (AEZ)						
	Arid/ Semi-arid	**Sub-humid**	**Humid**	**Highland Arid**	**Highland semi-arid**	**Highland sub-humid**	**Highland humid**
CORAF/ WECARD	Senegal Burkina Faso Nigeria	Nigeria Cameroon Burkina Faso Sierra Leone DR Congo	Sierra Leone Cameroon DR Congo Nigeria			DR Congo	
ASARECA	Kenya Ethiopia	Kenya Uganda	Uganda	Kenya Uganda Ethiopia	Ethiopia	Rwanda Kenya Ethiopia Uganda	Uganda Rwanda Kenya Ethiopia
CCARDESA	Zambia Tanzania	Zambia Tanzania	Tanzania	Tanzania*	Zambia Tanzania	Zambia Tanzania	Tanzania

* Tanzania is considered both in ASARECA and in CCARDESA

Table 2.2 Dominant farming systems in the countries selected

Country	Major Farming Systems[1]
Burkina Faso	AP, P
Cameroun	CR,RT
DR Congo	CR
Ethiopia	HM;HP;P;MM;CR
Kenya	P; HP;MM; FB
Nigeria	MM,R, CR,RT
Rwanda	HP
Senegal	AP,R
Sierra Leone	ASP
Tanzania, United Republic of	AP;MM;HP;RT;FB
Uganda	MM;HP;AP;FB
Zambia	MM;AP

[1] The farming systems are defined as AP = Agro-pastoralist; MM = maize mixed; P = Pastoralist; HP = highland perennial; CR = Cereal root-crop mixed; APO = Agro-pastoralist oasis ; HM = highland mixed; I = Irrigated; HL = Humid lowland tree crop; FB = Forest based; HP = Highland perennial; RT = Root and tuber crop; FB = Fish based; PM = Perennial mixed

2.5 Data and Information Collected

Data and information collected included 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 yield, indicators of development and governance, national policies and strategies, Data was collected with reference to the 2013 agricultural production season (which is considered a baseline year for this report) except as otherwise specified.

2.6 Limitations of the Report

The scoping nature of the study did not provide sufficient data for statistical analysis. Also, it was not feasible to obtain identical data sets from each of the selected countries. The break out of the Ebola virus in West Africa during the time of the study limited interactions and data collection in West Africa.

Plate 2.1 Women in agriculture

3. Climate Change in the Case Study Countries

3.1 General Trends for Africa

There has been a general increase in temperatures in the continent by over 0.5°C over the last 100 years (IPCC, 2013). Observed trends in annual rainfall over several decades show that temperatures have been rising significantly in many countries, while rainfall has shown increases as well as decreases. IPCC (2013) reported that East Africa has observed a 0.8-1°C increase in temperatures while West Africa temperatures have risen by 0.2-2.5°C with stronger warming in the northern areas including Mali and Niger. Temperatures are predicted to increase on average by 2-3°C by 2046-2065. Yearly rainfall averages will increase across the region, with more extreme increases of up to 25% in East Africa including Uganda, Rwanda, Burundi, and the DR Congo.

3.2 Burkina Faso

For the period 1961-1990, rainfall averaged, respectively, 900-1200mm, 600-900mm, 300-600mm in the south sudanian, north sudanian and sahelian. Annual rainfall at Ouagadougou fluctuated between 1920 and 2000mm but the overall trend was a decline from 860-650mm (Burkina Faso, 2007). Rainfall in Burkina Faso has been steady between 1992 and 2012 but was 15% below the 1920-1969 average (FEWS NET, 2012a). Between 1920 and 2000 average annual minimum and maximum temperature fluctuated but the overall trend was a rise in minimum temperature of 21-22.5°C and 34.7-35.2°C in maximum temperature. Average temperature increased by 0.6°C since 1975 (Burkina Faso, 2007; FEWS NET, 2012a).

Assuming an optimistic scenario (A1B[1]), CNRM-CM3 and MIROC 3.2 GCM models project increase in rainfall in large areas of the country, with MIROC 3.2 predicting the highest rainfall. On the other hand CSIRO Mark 3 projects decrease in rainfall of 200 to 100 mm in the central and south-western parts of Burkina Faso. ECHAM 5 projects small changes, that is, decrease of 50mm or increase of 50 mm in the entire country (Some, *et al.,* 2013). Projections of average daily maximum temperature are consistent between GCMs. Increases ranged from 1.1-2.7°C; CSIRO Mark 3 and MIROC 3.2 project increases of 2-2.5°C and 1.0-1.5°C respectively. CNRM CM3 and ECHAM 5 project 2.5 – 3.0°C (Some, *et al.,* (2013).

[1] A1B is GHG that assumes fast economic growth, a population that peaks mid century and the development of new and efficient technologies, along with a balance use of energy sources.

3.3 Cameroon

Cameroon is characterized by five agro-ecological zones with varied landscapes and climates. These are described as Zone I (Soudano-Sahelian); Zone II (High Guinea Savannah); Zone III (Western Highlands); Zone IV (Humid Forest with mono-modal rainfall pattern); and Zone V (Humid Forest with bimodal rainfall pattern) (Ndi, 2014). Records on temperature and rainfall from a number of stations in Cameroon suggest a rising trend in temperature around Yoaunde (Ndi, 2014). Rate of temperature change since 1900 to 1991 showed a net increase of 0.91^{o}C during the period; which is higher than the average global warming rate of 0.5^{o}C over the same period.

The predicted temperature in 2060 for Cameroon is 1.8^{o}C as compared to predicted global temperature in 2070 of 3^{o}C. With respect to rainfall, records show a general declining trend. When projected into the future, the trends indicate decrease in number of rainy days in 6 out of 11 weather stations in the country. Total amount of rainfall drops by about 280 mm during the entire period. There is also a drastic drop in the total amount of rainfall in the northern region.

A very prominent environmental feature of West and Central Africa is Lake Chad. Lake Chad sustains livelihood for farmers and for livestock production especially cattle. The health of the lake is therefore very critical. However there has been a severe decline in the size of Lake Chad (Figure. 3.1) and of its fisheries.

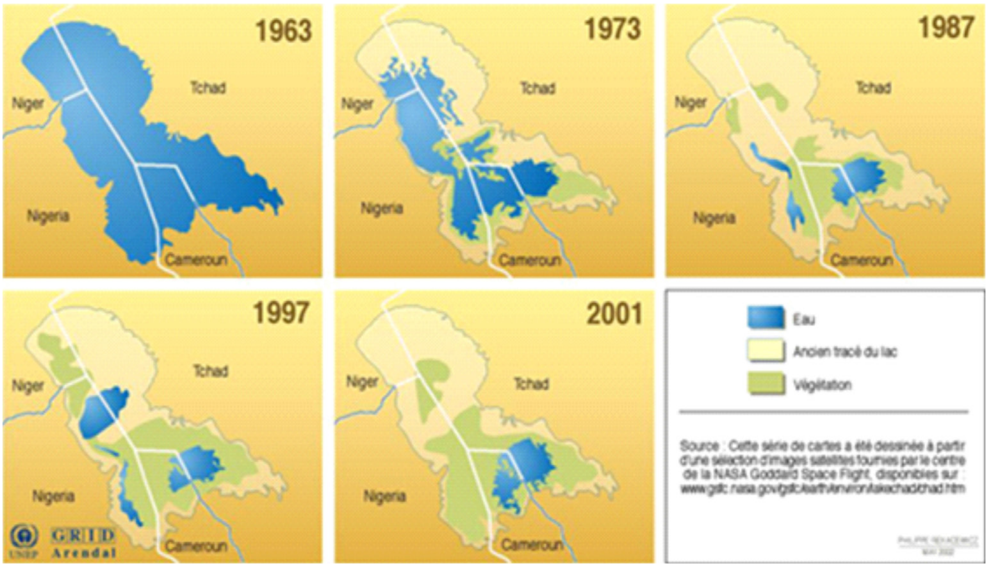


Figure 3.1 The reduction in surface area of Lake Chad (1963-2001)

Plate 3.1 Improved irrigation in Kenya

3.4 Democratic Republic of Congo (DRC)

DRC is a country of abundant rainfall which ranges between 900mm and 2400mm/annum, and a mean annual temperature of between 24 and 26°C (AfDB, 2013). The trends over the last few decades indicate a rise in temperature.

The projections are of increase in rainfall and gradual rise in temperature. It is projected that there could be increase in rains in the Cuvette region, but a shortening of the rainy season the farther south, especially in the savannah belt. In the Katanga region, the rainy season is projected to shorten by two months from 7 months to 5 months.

3.5 Ethiopia

Ethiopia is a large complex country, with complicated patterns of rainfall and livelihoods (Livelihoods Integration Unit, 2010). The seasonality of rainfall varies in different areas of Ethiopia. In the eastern Somali region, rains come twice a year (during March–June) Belg season, and (during 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, Belg and Kiremt rainfall, based on quality controlled station observations, decreased by 15–20 percent across parts of southern, south-western, and south-eastern Ethiopia. During the past 20 years, the areas receiving sufficient Belg rains have contracted by 16 percent. The average rise in temperature since 1900 has been 1°C.

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

3.6 Kenya

Temperature trends between 1960-2006 show general warming over most land locations except for the coastal zone that shows a cooling trend. 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 but minimum temperatures have either not changed or have decreased. The Fourth and the Fifth Assessment Reports of the Intergovernmental Panel on Climate Change point to the occurrence of extreme precipitation changes over Eastern Africa, including Kenya, such as droughts, heavy rainfall and occurrence of weather extreme events where, for example, 2003 was the wettest in 70 years in some parts of Kenya then followed by drought in 2006 with the country receiving only 50 per cent of expected rainfall.

Compared to the 1961-1990 average, a medium high emissions scenario produces warming of around 4°C by the end of the century. Under a Business As Usual scenario, with no actions to reduce global emissions, the average warming across all models shows temperature increases of approximately 4-5°C by the end of the century with individual models showing temperature increases approaching and exceeding 6°C in the same period. Under ambitious global greenhouse gas emission reductions (represented by RCP2.6) temperatures are expected to increase by approximately 1°C by the end of the century, but still approach 2°C for some models. Precipitation is projected to increase in most parts of the country as will variability, which is a point of concern.

3.7 Nigeria

There have been changes in Nigeria's rainfall and temperature regimes (NIMET, 2008; FMEnv, 2011) over the past decade. Between 1941 and 1970, only parts of the country, around the extreme Northwest and extreme Northeast experienced late onset of rains, but from 1971 to 2000, late onset of rains had spread to most parts, leaving only a narrow band in the middle of the country with normal conditions. In the same way, only a small part of the country in the South west recorded early cessation of rains between 1941 and 1970, while from 1971 to 2000, early cessation of rains covered most of the country. The combination of late onset and early cessation has shortened the length of the rainy season. Between 1941 and 2000, annual rainfall decreased by 2 – 8 mm across most of the country, but increased 2 – 4 mm in a few places, most significantly around the coastal South east. With respect to temperature changes, from 1941 to 2000, there was evidence of long-term temperature increase in most parts of the country. The central eastern axis showed slight cooling, while average temperature at the extreme northeast, extreme northwest and extreme southwest increased by 1.4 – 1.9°C.

The A2 scenario projects a temperature increase of 0.04^{o}C per year from now till the 2046-2065 periods (NASPA-CCN 2012). The coastal regions are projected to warm less than the interior regions because of the cooling effects of the Atlantic Ocean, and the northerly stations are expected to be warmer than the southerly stations. The highest increase is projected in the northeast. With respect to rainfall, the projected changes in rainfall vary across the country, with the A[2]2 scenario suggesting a wetter climate in the south, but a drier climate in the northeast. For the 2046-2065 period, the projected change ranges from an average increase of 0.4 mm/day in the south (15 cm annually) to an average decrease of 0.2 mm per day (7.5 cm annually) in the North.

3.8 Rwanda

There has been a significant increase in temperature of almost half a degree per decade (0.47^{o}C), taking average annual temperature towards 22^{o}C in 2010. This trend is more rapid than the global observed average reported in the most recent IPCC report of between 0.19 and 0.32^{o}C per decade for 1979-2005 (Trenberth, et al., 2007). No significant trend is found for rainfall over the period 1931-1990 but annual rainfall anomalies of up to approximately ±25% have been observed over the 1961-90 average. There is a high inter-annual variability for rainfall across Rwanda (Conway, 2002).

Climate Projections show increases for temperature, and precipitation. Median projections of temperature show a rise of around 1^{o}C by the 2020s, 1.5-2^{o}C by the 2050s and 2-3^{o}C by the 2050s. Median projections for precipitation of up to 7% increase by the 2080s under A2 (Conway, 2002). Changes in precipitation are more uncertain. Although the intensity, frequency and spatial distribution of precipitation are unknown, all the climate model scenarios show that average rainfall regimes will change, ranging from positive and negative anomalies across the models. The majority of the projections indicate that average annual rainfall will actually increase, particularly in some seasons, indicating a potential strengthening of the rains which is important in relation to flood risk.

3.9 Senegal

From 1960-1970 there was some stability in rainfall amounts but inter-annual variability in rainfall with average of 1200mm in the south (Kolda), and 500 mm in the east (Bokel). The period of 1970-1990 observed unstable climate, strongly marked by a steady drop in rainfall; an extreme drought in the Sahel that led to shortage in water resources. From 1990 -2000, there was an abundance of rainfall between 1990 and 2000. Rains have been steady in Senegal between 1992 and 2012 but were 15% below the 1920-1969 average (FEWS NET, 2012b). Average temperature increased from 27^{o}C in 1950 to 28.5^{o}C in 2000 (Senegal, 2007). Overall, temperature has increased by 0.9^{o}C since 1975 (FEWS NET 2012b).

For the optimistic scenario, all GCMs project very small changes of -50 mm to +50 mm in annual rainfall in most parts of Senegal. However, both CNRM-CM3 and MIROC 3.2 project increases of 50 -100mm in the Cassamance Region. ECHAM 5 however projects a marked

[2] A2 refers to high emission scenarios

reduction of 50mm to 200mm in annual rainfall in eastern Senegal. All models project temperature increase of 1-1.5°C. CSIRO Mark 3 and MIROC 3.2 indicate the lowest increase in temperature (Khouma, et al.,2013).

3.10 Sierra Leone

Average rainfall between 1961-1990 was 2346mm (GOSL, 2007). It varied between 3659mm in Bonthe (south) to 2618mm in Kabala (north). Average rainfall has fluctuated over time but overall rainfall has decreased since 1960. Between 1990-1999 it averaged 2891mm in Bonthe. Average temperature between 1961-1990 in Sierra Leone was 27°C (GOSL, 2007). It increased by 0.8°C since 1960 with average of 0.18°C per decade (Tarawalli,2012).

Johnson, et al., (2013), reported varied outcomes for rainfall for optimistic climate scenarios. The CNRM-CM3, CSIRO Mark3 and ECHAM5 global circulation models indicate rainfall varying by -50 to +50mm in most areas with an increase of 50 -100mm in 20% of the country, but the 3 models differ in terms of the specific regions that will experience this increase. MIROC 3.2 however indicate a severe reduction in rainfall in most parts of the country; reduction of -50 to -100mm in the north and -200 to -400 mm in the south. Concerning temperature, increases were always predicted; CSIRO Mark3 and MIROC 3.2 indicate increases of 1-1.5°C average daily maximum temperature. CNRM-CM3 indicates increase of 2-2.5°C throughout the country with the exception of a small area largely in the coastal area. ECHAM 5 predicts increases as high as 2-2.5°C and that increases would be greater in the north and northeast than in the rest of the country.

3.11 Tanzania

Rainfall patterns in the country are subdivided into: tropical on the coast, where it is hot and humid (rainy season March-May): semi-temperate in the mountains with the short rains (Vuli) in November-December and the long rains (Masika) in February – May: and drier (Kiangazi) in the plateau region with considerable seasonal variations in temperature. The mean annual rainfall varies from 500 millimetres to 2,500 millimetres and above. The average duration of the dry season is 5 to 6 months. However, recently, rainfall pattern has become much more unpredictable with some areas/zones receiving extremely low and high rainfall per year. Monthly minimum and maximum temperatures over the last 30 years (between 1974 and 2004) show upward trend at the analysed meteorological stations mostly associated with the months of January, July and December (URT 2007).

Climate projections show that the mean temperatures will increase throughout the country particularly during the cool months by 3.5°C while annual temperatures will increase between 2.1°C in the North Eastern parts to 4°C in the Central and Western parts of the country. Predictions show that the mean daily temperature will rise by 3°C – 5°C throughout the country and the mean annual temperature by 2°C – 4°C. There will also be an increase in rainfall in some parts while other parts will experience decreased rainfall. Predictions further show that areas with bimodal rainfall pattern will experience increased rainfall of 5% – 45% and those with unimodal rainfall pattern will experience decreased rainfall of 5% – 15%.

3.12 Uganda

Mean annual temperature has increased by 1.3°C since 1960, an average rate of 0.28°C per decade. Observations of rainfall over Uganda show statistically significant decreasing trends in annual and MAM rainfall. Annual rainfall has decreased at an average rate of 3.4mm per month (3.5%) per decade, but this trend is strongly influenced by particularly high rainfall totals in 1960-61. MAM rainfalls have decreased by 6.0mm per month per decade (4.7%).

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 current climate by 15-43% of days by 2060s. Projections of mean rainfall are broadly consistent in indicating increases in annual rainfall of -8 to +46% by the 2090s, with an average changes of +7 to +11%.

3.13 Zambia

Climate of Zambia can be distinguished for three regions based on their respective agro-ecological zones of semi-arid (I), highland semi-arid (II) and humid (III) where Region III is a higher rainfall area followed by Region II and lastly Region I with consistently lower rainfall. Region I is consistently experiencing climatic hazards in terms of droughts and water scarcity. Although the rainfall trends are contentious, there is a general tendency of rainfall declining and shifting towards dryness over the last decades.

The mean temperature scenarios for all the Regions show a similar trend of increasing mean temperatures for the period 2010 to 2070 of about 2°C (24.5 to 26°C). The HADCM3 Global Climate Model (GCM) was used show a general increase in rainfall in the three regions of the country (GRZ 2007)

3.14 Impacts on Crop Systems and Implications for Agriculture

In general, projected temperature increases are likely to lead to increased evaporation. Exactly how this increased evaporative loss will affect food production systems depends on factors such as physiological changes in plant biology, atmospheric circulation, and land-use patterns. As a rough estimate, potential evapo-transpiration over Africa is projected to increase by 5-10% by 2050. Increased variability of rainfall (i.e., deviation from the mean and occurrence of El Nino events) of crop production is also a major concern of farmers in Africa. Researchers have correlated past El Nino events and warm sea surface temperatures with more than 60% of the change between above and below average agricultural production of maize (Patt, et al., 2005).

Climate change may also impact the Africa's fisheries that have a critical thermal maxima in the food chain and some organisms cannot survive temperatures that exceed their threshold. Though tropical fishes can endure temperatures very near their temperature threshold, a slight (1 – 2°C) increase in regional temperatures may cause the daily temperature maxima to exceed their physiological limits (Roessig, et al., 2004).

As food production systems will be affected by climate change, adoption of new climate resilient technologies is required for farmers to evade impacts of climate change. Several factors (bio-physical, socio-economic and institutional) can influence farmer's capacity and williness to adopt new agricultural technologies and approaches including climate smart agriculture. Adaptation to climate change through CSA is possible only if farmers meet the minimum threshold levels in socio-economic and biophysical characteristics and obtain the necessary support from research in form of appropriate technologies and an enabling environment created through policies and institutions.

Across Africa, loss/reduction in crop yields, degradation of the ecosystem and loss of biodiversity was common feature for all zones. In the arid and semi-arid areas (sahelian zones) there is very strong erosion and land degradation, reduction in land area, lack of forage, reduction in numbers of livestock, incomes and labour force. Migration of men and youth takes place. In the Sudano-sahelian zone, there is reduction in crop yield, increased pressure on the land, and frequent conflicts between crop and livestock farmers.

The results of the GCMs used in conjunction with DSSAT gave similar results across Africa. For example, models project yield loss of 5-25% compared to the 2000 baseline. ECHAM 5 and MIROC 3.2 predict yield loss of sorghum greater than 25% in various parts of Burkina Faso while in Tanzania, maize losses is predicted to decrease by 10-84% making an average of 33% loss (URT 2007). However, increases in cereal yields of up to 25% have also been reported in scattered areas but in quantities that cannot offset the reduction leading to a net negative impact on cereal production across Africa.

Against the 2000 base line year, CNRM-CM3 and CSIRO-Mark3 show yield increases of rainfed rice and maize of 5-25% throughout Senegal. ECHAM5 predicts the greatest yield reductions, although there would be no change in some parts of the country and indeed some increases. For groundnut, the models show decreases as well as increases in yield but that there would be decreases in most of the country. In Tanzania, for tree crops such as, coffee production is projected to increase by 18% in bimodal rainfall areas and 16% in unimodal rainfall areas. There is agreement in projections by most models. Most models show yield loss of 5-25% for groundnut and CNRM-CM3 and ECHAM 5 projected yield loss greater than 25%. However there are small areas for which CSIRO and MIROC project yield increase.

Loss of agricultural land has been reported in Senegal and Rwanda resulting from increase in rainfall leading to increased erosion. In Senegal, there has been a reduction in crop yields (30-60%), increase in rural poverty, and food insecurity for all zones as climate change impacts.

The lessons from the analysis of the impacts of climate change show crops and regions will be affected differently by climate change with some areas reporting reduction while others increase in yields. The interaction between the new sets of climate parameters under climate change such as temperature, rainfall amount and pattern will influence crop growth and ultimately crop yield in Africa. Crop yields will also be influenced by the range of climate hazards that influence capacity of land and other farming resources to produce food.

CSA must therefore deliver increased and stable yields and improved livelihoods through developing new CSA technologies and innovations, improving uptake of the improved technologies, and facilitating availability of safety nets and weather- based insurance schemes.

3.15 Impacts of climate change on Livestock Systems

Climate change has contributed to modifications in transhumance patterns in arid and semi-arid zones of Africa, which has narrowed the movement of pastoralists especially in Senegal (Msangi, 2014). There are few models dealing with livestock and none, deal with heat or water stress which are crucial for the pastoral communities (Msangi, 2014). Thornton, et al., (2006) projected drop in length of growing period (LGP) that will negatively impact both livestock and crop systems with serious implications for food security. Lessons from Burkina Faso, Tanzania, Kenya, Ethiopia and Senegal show that impacts in the semi-arid livestock systems are projected to be stronger compared to areas that receive higher rainfall.

Climate change is responsible for the emerging and increase of pests and diseases. Drought and rising temperature also leads to shrinkage of rangeland resources (water and quality and quality of forage) exacerbating conflicts between livestock keepers and farmers (URT 2007). Animal losses are directly linked to rainfall. Thornton, et al., (2006) compared losses of livestock among three west African countries and found out that the animal losses in Burkina Faso was the highest (>20%) in at least 50% of the system compared to Sierra Leone with a moderate losses (5-20%) in at least 50% of the system, that is closely related with the amount of rainfall received in the areas. It is imperative that efforts should be directed towards climate smart livestock technologies and management strategies that provide opportunities for farmers to enhance provision of rangeland resource to compensate for the reduction resulting from climate change.

3.16 Implications for Markets, Finance and Policy

Change in length of growing period resulting from rainfall and temperature changes would have implications for crop and livestock production and ultimately affects trade. Regional and international trade flow patterns for key agricultural commodities could move from countries of higher agricultural yields and comparative advantage to countries of with current lower yields but future comparative advantage. Improved access to markets both locally and internationally would provide a driving force for increasing agricultural productivity. To counter predicted drop in agricultural production, risk management strategies, financial support in the form of investments and smart subsidies for the poor small scale farmers to enable them adopt CSA should be considered by governments.

4. Successful Climate-Smart Agricultural Practices in Case Study Countries

4.1 Adaptation and Mitigation Practises in Use

A number of CSA technologies are in use in the different AEZ in Africa. Their potential contribution to agricultural production, adaptation and mitigation of climate change impacts are shown in Table 4.1. These are aggregated as production, resilience and mitigation.

Adaptation/mitigation measures reported in the survey to be in use across the sahelian to sudanian zones are short duration crop varieties; vegetable production; integrated soil fertility management; soil and water conservation techniques (zai pits, stone bunds, ridges); crop associations; use of small doses of animal manures, fertilizers (micro-dosing) and pesticides; composting; restitution of crop residues to the soil; restoration of degraded lands; agroforestry (*Faidherbia albida* parkland); association of crops with *Guiera senegalensis*; assisted natural regeneration; use of lowlands; small scale irrigation; agricultural mechanization and cloud seeding. In the livestock sector, they include use of livestock breeds tolerant to heat stress and poultry production.

In the sub-humid zone, the system of rice Intensification and revival of the use of traditional crops such as sesame and fonio are being promoted. In the sub-humid-humid zones for example of Sierra Leone, the main adaptation/mitigation measures reportedly in use include swampland farming; short duration and drought tolerant crops; adjusting of farming calendars; dry season cropping; increased processing of crop produce; increased processing of livestock produce; intercropping; crop diversification and multi-storey tree crop farming (for example in cocoa plantations). Many of the practices in use were recommended by the extension services of governments and NGOs, but quantitative information on adoption rates is unavailable

In addition to these technological practices in use, adaptive capacity of farmers is being built through the following: participatory farmers field schools; support for improving security of land tenure; providing training on how to manage conflicts among community members and between livestock and crop farmers, advocacy skills on long term access to land and the development of land agreements; support for improving collection and dissemination of meteorological data by Meteorological Departments to guide farmers decision making on date of planting, choice of crops and support for Village Savings and Loans Associations (VSLA) and training on business skills (Katta, 2012; Danyi,2012).

Table 4.1 Contribution of CSA to production, adaptation and mitigation

	AEZ[a]	Practices	Aggregate Assessment		
			Production	Resilience	Mitigation
Soil fertility	S,SH,H	Nitrogen fertilizers (eg urea)	+++	+/-	-
	S,SH,H,	Integrated nutrient mgmt. (eg 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	Micro-catchment (eg zai, microbasin, Terracing)	++	++	
		Rainwater catchment, storage, Delivery eg 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	++	++	

	AEZ[a]	Practices	Aggregate Assessment		
			Production	Resilience	Mitigation
	S,SH.H	Sentinel warning system (droughts, pests)	+	++	+

[a] AEZ presented in Figure 2.1 are compressed in Table 4.1 into three zones which are: Semi-arid (incorporating Arid, highland arid, highland semi-arid and Semi-arid zones), Sub-humid (sub-humid and highland sub-humid) and humid (humid and highland humid) zones following FAO (2013), CCAF (2014).

4.2 CSA Best Bets

This section deals with examples of Best Bet Practices as reported by key informants in the 2014 FARA survey. They include relevant success stories in Africa previously reported by other researchers (for example 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). Success indicators of selected Best Bets are summarized in Table 4.2. Quantitative evidence of adoption rate was generally lacking but key informants estimated adoption to be low to moderate.

Climate Smart Villages

This is a community-based approach. CCAFS in collaboration with NARES, NGOs, agroecological zones and local authorities developed a model for improving adaptive capacity of communities in all zones. CSA interventions are tested and validated in an integrated manner, to boost farmers' ability to adapt to climate change, manage risks, build resilience, improve livelihoods and incomes and reduce GHG emissions where possible. The technologies and approaches utilized include index based insurance, gender research training; farmer learning networks for example exchange visits. The project was launched in 2011 in villages in Yatenga in Burkina Faso, Kaffrine in Senegal and others in West Africa. Because of its success it is being extended to other villages (Zougmore, 2014a). Chololo Eco village, an initiative funded by EU to improve livelihood of the poor in an arid area of Central Tanzania has been showing good results in mitigation to climate change (www.chololoecovillage.wordpress.com, Kalumanga et al., 2014).

Contour Bunds/Zai

In the arid and semi-arid zones harvesting of rainfall is crucial as rainfall is very low, erosion high and the soil degraded. The construction of stone bunds along contours is a proven technology of reducing runoff. Combined with zai pits (Plate 4.1) (filled with compost or manure) increases of sorghum and millet yields of 1t/hectare (100%) over unimproved land have been recorded. Traditionally, the zai technology consists of tiny pits (10 cm in diameter and 5cm deep, dug with hoes to break surface crusts during the dry season; the improved method involves larger pits (20-50cm in diameter and 10-25cm deep) which stores more rainfall and runoff.

Plate 4.1 Zai pits in West Africa (semi-arid AEZ)

Contour bunds have been established on 200,000-300,000 hectares of lands in the Sahel. The major constraint to adoption is initial cost which can be about $200/hectare and 150 person days of labour/hectare (Neate, 2013). Stone bunds and half-moons led to crop yield increases of about 25-60% and use of improved varieties resulted in crop yield increase of about 25% in the sahelian zone in which they are used.

Chololo pit is another indigenous in situ rainwater harvesting developed and practiced in Dodoma Rural District in Tanzania. Chololo pits, which are effective in heavy soils rather than loamy soils (Tumbo, et al., 2012), consists of small pits of 22 cm diameter and 30 cm deep, dug along the line at 60 cm space between pits in a row and 90 cm between rows of pits. Chololo pits are made with soil bunds around the pit to help retain rain water, farm yard manure and compost, and 1 to 2 maize/sorghum/millet seeds can be planted per pit (Munguambe, 2007).

Contour furrow

Furrows and ridges made against the slope (along the contour) with furrow upslope and ridge down slope conserve water and avoid soil erosion. The furrows which are used to trap rain water and are closed at the end to prevent water flowing out of the furrow at the end of the furrows are suitable for inter cropping especially cereal and beans. Contour bunds are laborious to construct and are usually used for production of high value crops such as vegetables. Generally contour farming is more effective in areas with slope of 4 to 6%, and all farm operations are done along the contour (Mati, 2007). Contour can be permanent and associated with vegetation planted on the furrows.

In the 700- 1100mm (sub-humid) rainfall areas, this system of soil and water conservation gave increase in production of grain and straw of 20% and 30% respectively; increase of soil carbon in the order of 14% after 2 years; increase in soil water storage of 50-103%;return on investment of 20-60 % after 2 years of installation in Senegal

Association with agroforestry

Farmers in the semi-arid zone allow tree stumps (*Faidherbia albida* or *Piliostigma reticulatum*) to regenerate and cut leaves are left on the surface as a green manure.

Faidherbia albida (Plate 4.2) sheds its leaves at the start of the rainy season, thus increasing soil organic matter content. In the 300-500mm (semi-arid) rainfall areas, this system involving crops/livestock integration resulted in increase of milletand groundnut yields by 150% and 44% respectively; increase in carbon stocks of 60%; increase in incomes; reduction in droughts due to increased relative humidity, reduced potential evapotranspiration, and reduced temperatures in Senegal. In Zambia, the practice increased maize yield from 2.8 ton/ha to 7 ton/ha (GoZ, 2007)

In the 300-500mm (semi-arid) rainfall areas cropping with tree crops such as *Guiera senegalensis* and *c. spectabilis*, the system resulted in increase in millet yield of about 245% and groundnut yield of 20%; increase in carbon stocks in soil and biomass; increase in incomes, reduction in vulnerability to droughts and reduction in wind erosion.

Farmer Assisted Natural Regeneration

In the 150-700mm (semi-arid) rainfall areas, assisted natural regeneration, resulted in yield increase of millet greater than 150%;improvement of carbon stocks in soil and biomass; increase in incomes; reduction in vulnerability to droughts; reduction in wind erosion; increase in wood production in Senegal.

Source: Liniger et al., (2011)

Plate 4.2 Faidherbia albida in parkland (semi-arid AEZ)

Stone Bunds and Half Moons

The villages of Santhie Serer, Kessoukhatte and Landou in the Niayes region of Senegal participated in the Agrobio Niayes Programme of ENDA-Pronat. Women played very active roles (decision making) (Plate 4.3) in the Anti-erosion Committee as well as participated in the installation of soil and water conservation devices including stone bunds, half-moons and vegetative strips. The results were striking; flow of rain water slowed down, vegetation was regenerated and it took 1-1.3 hours to draw up water from wells where it used to take 2-3 hours (WEDO,2008).

Source: Lineger et al. (2011)

Plate 4.3 Stone lines/bunds in semi-arid West Africa

Table 4.2 Bio-physical and socio-economic characteristics where selected CSA practices are used

Climate mart technology	AEZ/	Land size	Land User	Land Owner	Soil Type	Terrain	Level of Mech.	Skills/ knowledge	Labour requirement
Integrated Soil fertility Management									
Microdosing	Sub-humid Semi-arid	1-2ha, Partly 2-5ha	Small scale, poor	Family, Individual	Sandy to sandy loam	Flat to gentle	Manual, Equipment	moderate	Moderate
Conservation									
Agriculture									
Min. Tillage/ Direct planting	Humid, Sub-humid, Semiarid	1-2ha, Partly2-5ha	Small-scale, Poor	Family, Individual	Wide range of types	Flat to gentle	Manual, equipment	high	Moderate
Water Harvesting									
Zai pits	Semiarid	2-5ha	Small-scale, Poor	Family, Individual	Well drained, sandy, crusting	Flat to gentle	Manual, equipment	moderate	Initially high
Cross slope Barriers									
Stone bunds/ Veg. Barriers	Mainly Sub-humid Semi-arid, partly Humid	1-5ha	Small scale, poor	Family, individual	Not suitable for very shallow and sandy soil	Gentle to steep slopes	Mainly animal traction, manual	High level to establishand maintain bunds	High
Agroforestry									
Parkland	Semiarid	1-5ha	Poor, better off	Family, individual	Sandy loam, low organic matter content	Flat to gentle	Manual	moderate	Moderate
Famer assisted Natural Regeneration	Semi-arid	1-5ha	Small scale, Poor	Family, Individual,	Low soil fertility,	Flat to gentle	Mainly manual, partly Animal traction	moderate	Moderate
Lowland rice cropping	Humid, sub-humid	1-5ha	poor, better off	Family, individual	Low soil fertility, medium texture	Flat	Manual, power tiller	Moderate	Initially moderate to high depending on standard of swamp development

Source: Adapted from Lineger et al.(2011); FARA survey(2014)

Seasonal Weather Forecasting

Seasonal weather forecasts (an aspect of climate risk management), provided in useful and understandable ways to farmers, facilitate decision-making in agriculture in all agro-climatic zones. Based on understanding of indigenous knowledge, CCAFs together with the meteorological agency (ANACIM) developed seasonal rainfall forecasts. The information provided includes total rainfall, the onset and end of the rainy season and a 10 day forecast across the rainy season. The approach was piloted in the Kaffrine region of Senegal since 2011 but forecasts are now being made through a radio network in Kaffrine, Thies, Diourbel, and Louga regions. It is estimated that millions of users are now benefiting from the service (Zougmore, 2014b).

Lowland Rice Cropping

Lowland rice cropping, with or without fertilizers,(which may be followed up with vegetables in the dry season) makes it feasible for farmers to reduce deforestation and bush fires in the uplands thereby mitigating GHG emissions. In Sierra Leone it gave 72% rice yield increase over upland rice (WFP,2008; IFAD,2010) in the rain forest zone, and 78 % yield increase over upland rice and 270% increase in returns to family labour in the savannah woodland (Spencer et. al., 2009).

Conservation Agriculture

CARE, implemented a project on conservation agriculture (mulching, minimum tillage, cover cropping, crop rotation) in the savannah woodland of Sierra Leone from 2010 to 2012. On average, yields of maize, rice and groundnut increased by over 100% compared to the baseline year (conventional practices), but were still very low in 2012 (268kg/hectare, 1009kg/hectare, 590kg/ha for maize, rice and groundnut respectively. Soil organic carbon in plots under conservation agriculture ranged from 1.22% to 4.53 % and averaged 2.5% in 2010, the first year of implementing conservation agriculture. In 2011, organic carbon varied from 2.01% to 5.89% and averaged 3.09% indicating a substantial increase in soil carbon storage (carbon sequestration). Soil temperature and hardness measured on plots under conservation agriculture were less than the baseline values (Danyi, 2012; Katta, 2012).

Agroforestry

Bjorkemar (2014) estimated the potential incomes from various agroforestry practices, boundary planting, dispersed interplanting, fruit orchards and woodlots in the humid and sub-humid zones. Dispersed interplanting and border planting gave negative returns at the plot level (1-2 ha). However, when extrapolated to the village level, returns for all systems were positive; $ 15,470, $135,812, $5,427,800, and $11,903,090 for dispersed interplanting, boundary planting, woodlot and fruit orchard respectively. At the village level, estimated carbon storage was 1680 t CO_2/hectare, 5,100 t CO_2/hectare, 18,300t CO_2/hectare and 42,000t CO_2/hectare for boundary planting, fruit orchard, dispersed interplanting, and woodlot respectively (Table 4.3). The mitigation potential of these systems is therefore low at the small scale but increases with upscaling. Agroforestry offers the potential of diversification of incomes of small scale farmers and soil conservation. Data on estimates of carbon across countries for different agro-practices and livestock production systems were not available.

Table 4.3 Projections of Carbon stored by agro-forestry systems in the savannah woodloans of Sierra Leone over 25 years

Area	Boundary plantings(per 100m)	Dispersed interplanting	Fruit orchard	Woodlot
		(t CO_2/ha)		
1 ha	5.6	61	17	140
2 ha	11	122	34	280
25 ha	140	1,525	425	3,500
50 ha	280	3,050	850	7,000
Village	1680	18,300	5,100	42,000
Chiefdom	47,040	512,400	142,800	1,176,000
District	1,223,040	13,322,400	3,712,800	30,576,000

Source: Bjorkemar (2014); FARA Survey, 2014

Adapted Crop Varieties

The benefits of improved crop varieties is 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 agroclimatic zones and countries. They give yield increase often more than 100% over local varieties. Well known examples are NERICA (upland rice) and drought-tolerant maize varieties. These improved varieties used in conjunction with the Sustainable Land Management practices increase yields and productivity considerably are available for maize, millet, sun flower, sorghum and cassava.

5. Policies/Strategies/Plans and Programs Promoting Climate Smart Agriculture

5.1 Climate Smart Agriculture Policies

At the global level CSA has gained support and earned promotion as part of a solution to climate change problems (CCAFS, 2012). It is supported by organizations such as the UN Food and Agriculture Organization (FAO) and the World Bank, and was backed by a number of heads of states and the former UN Secretary General Kofi Annan at the United Nations Climate Change Conference (COP17) in Durban South Africa in 2011.

A review of literature and policies across the African region however showed that there are no national policies specifically aimed at adoption of climate smart agricultural technologies. The key to developing appropriate policies, strategies and actions to enhance CSA adoption is to understand the barriers to adoption of CSA practices, including the trade-offs between short-term costs and longer-term benefits, the mix of private and public benefits, institutional and financial barriers as well as lack of access to inputs or markets (FAO, 2012b). Some countries like Ethiopia and Tanzania are working hard towards climate smart agriculture. The main reason why these countries have such focus is because of their environmental ministries being placed high up in the power hierarchy. In Ethiopia for example, the lead institutions shaping current climate response in agriculture is the office of the Prime Minister (DFID, 2011) while in Tanzania, it is the Office of the Vice President.

5.2 Regional Policies Supporting CSA

There are a number of institutions with policies that promote CSA across Africa. These include regional blocks such at the EAC, ECCAS, ECOWAS, COMESA, and SADC. Following such regionalization, CSA issues are addressed through the agriculture R&D platforms to execute this objective better, SROs for FARA; ASARECA, CCARDESA and CORAF partner with other agencies to promote CSA in Africa. The Forum for Agricultural Research in Africa (FARA), in response to NEPAD's request, developed the Framework for African Agricultural Productivity (FAAP). The purpose of FAAP is to guide stakeholders in African agricultural research and development to meet the objectives of CAADP pillar IV with regard to: (i) strengthening Africa's capacity to build human and institutional capacity; (ii) empowering farmers, and (iii) strengthening agricultural support services. FAAP works at the continental, sub-regional and national level to increase agricultural growth and to complement the other three pillars of CAADP. (See Section 6.1)

The role of Sub-Regional organisations such as ASARECA, CORAF and CCARDESA is to assist the continental level aspirations for transformation in agriculture and CSA, working closely with national actors. SROs are positioned to contribute towards achieving the AU/NEPAD vision by using strong partnerships at all levels. They 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 other advanced agricultural research centers.

Decision makers such as Ministers for Agriculture and Food Security have to ensure dialogue, synchronization of policy and programs between SROs and countries policies and targets. Engaging various stakeholders ensures that opinions are taken care and well communicated. The process of engaging stakeholders must be done carefully to assure inclusiveness (small, medium and large farmers and various categories of actors – NARs, universities, financial institutions) and effectiveness of their agricultural R&D programmers. Collaboration with various international development partners can just promote CSA; however, linking with FARA will assure effective agriculture transformation across Africa (Akinbamijo, 2014).

5.3 National Policies/Adaptation Programmes of Action

The NAPAs were intended for Least Developed Countries to identify activities that respond to their urgent and immediate needs to adapt to climate change. Kissinger et al., (2003) reviewed the NAPAs of Senegal and Sierra Leone. The CSA factors considered in the analysis were: cross sectoral cooperation; stakeholder involvement; proportion of adaptation projects in agriculture; adaptation projects with elements of mitigation; adaptation projects related to food security and gender. He concluded that in general, they met the minimum criteria but that the documents did not seem to recognize that adaptation measures can have mitigation elements. The Tanzania NAPA comprehensively outlines potential adaptation activities which are Climate Smart for the various sectors, including Crops and Livestock as follows;

Crop sector

The array of actions that are possible in the crop sector include: Alternative farming systems, Promotion of indigenous knowledge, Changing planting dates in some agro ecological Zones, increasing irrigation to boost maize production in selected areas, Drip irrigation for specific regions, Reducing reliance on maize as staple food by growing short-season and drought tolerant crops such as sorghum and millet, Shifting crop farming to more appropriate agro-ecological zones, Changing crop rotation practices, Integrating crop and pest management, Making better use of climate and weather data, weather forecasts, and other management tools, Creating awareness on the negative effects of climate change, Sustainable water management to boost food crop production and Strengthening early warning system, Promotion of standard agronomic practices and Promotion of annual and short term crops

Livestock Sector

In the Livestock sector NAPAs often include actions to deliver; Change land use patterns, Tsetse fly control, integrated pest and disease control, Sustainable range management, Infrastructure development, research and development, Education of farmers/livestock keepers, advocating zero grazing and controlled movement of livestock.

Plate 5.1 Small ruminants such as goats can improve farmer income

Value of NAPAs

So far, the NAPAs[3] haves 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, temperatures changes, vulnerability to climate change and sectoral analysis (i.e., agriculture, livestock, forestry, water, coastal and marine, and energy), Agro Ecological Zones 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. Adaptations plans however, differ in their depth of coverage from country to country. The comprehensiveness of the NAPA for Tanzania might have been due to its location in the Office of the Vice President.

However, not all countries have NAPAs in place and their dates of publication differ. With the presence of NAPAs climate change adaptation is more focused and coordinated. Botswana which is lacking an adaptation plan, admits that it is key to identifying priority adaptation actions that reduce vulnerability and build resilience as well as identifying programmes to address poverty in the context of a changing climate. It was reported that the consultation process and compilation of the climate change policy in Botswana was expected to be completed by July 2014. Finalisation of such a policy will enable the country to have its

[3] The Nigeria equivalent is the National Adaptation Strategy and Plan of Action on Climate Change in Nigeria (NASPA-CCN)

adaption plan. The analysis for NAPA for Rwanda Tanzania and Zambia shows that 83.3 %, 40 % and 66.7 % of the programs are direct linked to promotion of CSA. Rwanda, Tanzania and Zambia have a total of 6, 10 and 6 projects/options in their NAPA document.

In Africa, the process of preparing the NAPAs has been consultative, drawing from wider policies and involving various sectors ensuring the inclusiveness and sustainability of the proposed programs / projects. In all the countries presented, NAPAs are linked with other national development policies, goals, objectives, plans, strategies and programmes and support/complement strategies and programmes of multilateral environmental agreements related to CSA that the countries have ratified. The strongest of the international conventions that support CSA include;

i) United Nations Framework Convention on Climate Change (UNFCCC),
ii) The United Nations Convention to Combat Desertification (UNCCD),
iii) The Convention on Biological Diversity (CBD),
iv) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal,
v) Vienna Convention on the Protection of Ozone Layer and Montréal Protocol on Substances that Deplete the Ozone layer.

5.4 Poverty Reduction Strategy Papers (PRSP)

For CSA to thrive, there should be enabling policies and strategies beyond the agricultural sector e.g. on safety nets, energy, education, health, trade orientation, national budgets as should be reflected in the Poverty Strategy Reduction Papers. They are termed the Strategy for Accelerated Growth and Sustainable Development (SCAAD) 2011-2015, the National Strategy for Economic and Social Development (NSESD) 2013-2017 and the Agenda for Prosperity 2013-2018 for Burkina Faso, Senegal and Sierra Leone respectively. They meet minimum criteria of a comprehensive overarching multi-sector approach to national development, the importance given to agriculture and food security, the recognition of climate change as one of the threats to improving agricultural productivity, participatory development and implementation, and gender considerations. In all countries surveyed, the PRSPs have been important policy document to prepare National Budgets, NAPAs and various programs such as the NAFSIPs. This has been key to ensure the inclusiveness of concern of the majority; the CSA.

5.5 Other Policies, Strategies and Plans Supporting CSA

What is emerging is that most of the countries in Africa have either a climate change policy or a National Climate Change Strategy and Action Plan or NAPA/NAP/NASPA, NEMA etc. All countries have identified agriculture as important for both adaptation and mitigation which is important as an entry point for negotiation for CSA. There is need to build synergy between the NAIPs/NAFSIPs and the National Climate Change instruments in those aspects dealing with agriculture in order to realize the vision of widespread adopting CSA by the African farmers.

Some nations have attempted to develop strategies that allow local authorities in the countries to develop plans that could enable CSA to be implemented at local levels without necessarily requiring approval or support from the national authorities. These strategies include Rural Development Strategies, the Agriculture Sector Development Strategies and the general devolution in governance to district that is practiced in diverse forms across the continent.

6. Gaps and Investment Opportunities

6.1 The Comprehensive Africa Agriculture Development Programme

The AU-NEPAD Agriculture Climate Change Framework (AU-NEPAD,2010), was designed as an agriculture/ climate change strategic tool for building capacity and addressing aspects of alignment, harmonization and financing amongst partners as well as a way to help African countries define and determine their agendas on agriculture/climate change and build informed leadership and responsibilities.

Principally, CAADP delivers through four pillars namely namely, Extending the area under sustainable land management and reliable water control systems; Improving rural infrastructure and trade-related capacities for market access; Increasing food supply and reducing hunger and Agricultural research, technology dissemination and adoption. CAADP aims at assisting African nations raise agricultural productivity by at least 6% per year and this can be made possible through managing its second aim which is for African countries to increase public investment in agriculture to 10% of national budgets

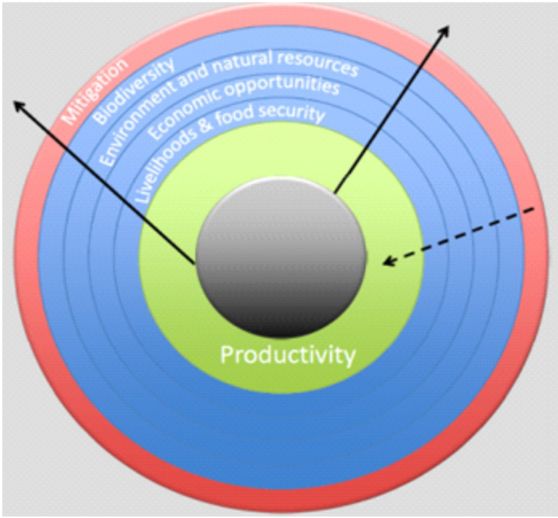
The framework provides guidance to national and regional initiatives on programmatic approaches on knowledge generation, knowledge management and technology transfer and financing upscaling, based on adaptation and mitigation measures, including sustainable land and agricultural water management. Specifically, 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 and opportunities and challenges of up scaling.

CAADP contributes to agricultural development in Africa at two levels as follows, (i) Agriculture's Contribution to economic growth and inclusive development and (ii) Agricultural Transformation and Sustained agriculture growth.

Agriculture's Contribution to economic growth and inclusive development

The CAADP framework provided guidelines to promote Wealth creation; Economic opportunities and Prosperity – jobs & poverty alleviation; Better Nutrition; Environmental resilience and sustainability and improved food security and productive safety nets. At this first level, CAADP provides an opportunity for implementing CSA for communities to reap benefits through carbon funds and public-private partnerships and create wealth (results i and ii), improve nutrition through increase productivity results (iii and v) and climate change adaptation and mitigation (result iv). Through this level of the results all the six spheres (Figure 6.1) of the CAADP CSA framework are addressed. While increasing agricultural production and productivity is the fundamental goal, the initiatives should in one way or another address adaptation and mitigation, hence Climate Smart Agriculture.

Figure 6.1 The six spheres of CSA for increasing productivity, resilience and mitigation



Source: AU-M

Note: The focus starts from the inner circle with the highest importance.

Agricultural Transformation and Sustained agriculture growth

The four expected result areas are identified as:

i) Increased agricultural production and productivity
ii) Better functioning national agriculture and food markets & increased intra/inter-regional trade,
iii) Expanded local agro-industry and value addition
iv) Improved management and governance of natural resources for sustainable agricultural production

6.2 Gaps/Investment Opportunities within the CAADP Framework

Various challenges have been retarding the growth of Climate Smart Agriculture in Africa as anticipated by CAADP and the NAFSIPs. Among them are production and commercialization challenges; integrating production and mitigation; scientific capacity to improve adaptation-mitigation responses; lacking policy support for climate risk management; policy and institutions gaps and financing. The CAADP framework however, requires related national policies and institutions to be in place for implementation of CSA. The FARA survey has shown that these challenges can be seen as investment opportunities to intervene within the CAADP framework.

Production and Commercialization

All the NAFSIPs in the countries surveyed focus on production, but crop and livestock yields are low. Production has not kept pace with the demand of growing and urbanized populations. Commercialization is an important aspect of all NAFSIPs and value addition is being promoted but the trade balance is negative in favour of developed countries, while regional trade is undeveloped. The ECOWAS protocols on free movement of goods and persons across borders is an example of such a protocol that is not fully implemented at national levels. The NRC (2010) reported harassment of traders by immigration, customs and police officers at border posts.

Adaptation-Mitigation Integration

In support of the NAPAs, the NAFSIPs have emphasized short term adaptation. The mitigation elements of adaptation programmes such as Sustainable Land and Water Management are generally not recognized as such. For example, the Senegal NAPA clearly states that carbon sequestration and reduction of land degradation are considered as longer term options, underlying the priority placed on adaptation and reflecting the little recognition of the potential for synergies between adaptation and mitigation

Scaling of CAADP activities

CSA can be practiced at the plot, farm and landscape levels (CAADP, 2010). Most of the CSA measures reported in the policy and strategy documents of Burkina Faso, Senegal and Sierra Leone deal with plot and farm level options. One of the few landscape- level measures mentioned is the protection of the pastoral zone in Burkina Faso. Most of the adaptation/mitigation options reported are for crops and livestock seem to be neglected even though the NAPAs and National Communications to UNFCCC show that livestock is a major contributor to GHG emission.

Scientific Capacity to Improve Adaptation-Mitigation Response

The General Circulation Models (GSMs) commonly in use by the climate science community were developed outside Africa, and for Africa are data poor. They sometimes project inconsistent impacts on agriculture in Africa. While there is substantial capacity at the CGIAR centres, there is inadequate national capacity on modelling of climate scenarios and impacts on annual crops, tree crops and integrated pest management and livestock. Physical resources are generally poor especially in a country like Sierra Leone which went through a civil war during which most of the meteorological and hydrological stations were destroyed. The NAFSIP of Burkina Faso and Senegal recognize that agricultural research is critical to successful CSA, but that of Sierra Leone does not have research elements. National research institutes (INERA, ISRA, SLARI) and their partner universities rely on CGIAR centres for strategic research.

Policy and Institutions

All the countries in this study are in the early stages of implementing their NAPA's and do not have detailed concrete plans consistent with an overall adaptation strategy (Kissinger, 2013) and most of the projects have not been funded. Although many NAFSIPs have elements of CSA there are no specific policy instruments focusing on CSA *per se* in all NAFSIPs even though the climate smart agriculture paradigm was in operation before the development of the NAFSIPs (FAO, 2010). In addition, they are focused on immediate visible impacts and do not prepare for the projected medium term impacts or long term impacts.

Regarding policy support for climate risk management, weather indexed- based insurance schemes are being developed as part of the Climate Smart Villages concepts. There is no policy support for climate risk management in terms of insurance schemes for farmers in Sierra Leone, but an entire aspect of the Small Commercialization Programme is on social safety nets.

In his review of the CAADP process in Burkina Faso, Loada (2014) observed that institutions responsible for agricultural policy suffer from capacity gaps. The root causes of which include (1) lack of relevant data and data production capacities resulting in documents that are superficial or incomplete with errors of design, and allocation (2) lack of skills in forecasting, strategic analysis, and ex-ante evaluation related to net benefits of investment options (3) legislative and regulatory frameworks and tools used for funding issues are usually not well known (4) inconsistency between various regulatory authorities. Institutions in the agricultural sectors.

Finances

Externally funded expenditure as a percentage of total agricultural expenditure has been significant. For Burkina Faso, it was 18% in 2005 and 20% in 2001; for Sierra Leone, it was a very high 82% in 2009 and 71% in 2011 (ISO, 2014). The NAFSIPs in all countries still have large gaps in funding and are heavily reliant on donor funds. Although there is no precise figure, both adaptation and mitigation actions required for future agriculture are projected to lead to significant increases in financing, and gaps are expected to widen if innovative methods of financing are not found. Support to adaptation projects has been through separate funding mechanism from mitigation projects even though some adaptation projects have mitigation aspects. Because industries in the private sector of many developing countries are young, it is difficult for them to perceive their role in contributing to GHG emissions and therefore to finance CSA research.

A number of countries have prepared National Agriculture and Food Security Investment Plans (NAFSIPs) to integrate the scaling up of practices that augment development, food security, and climate change adaptation and mitigation. The investment plans of many African countries in the region show that about> 50% of their planned activities are expected to generate climate benefits in terms of slow-onset climate change, about 18% to generate benefits in terms of adaptation to extreme events such as extreme drought, high evaporation, and strong and 20% to mitigate against climate change.

Various countries within Africa which ratified the CAADP process have finalized NAIPs, namely, Rwanda (currently preparing 2nd cycle), Kenya, Malawi, Uganda, Burundi, DR Congo, Djibouti, Ethiopia, Tanzania and Zambia; and Zimbabwe. Most CAADP Country Investment Plans (CIPs) have identified land and water management as priorities and endowed them with significant budgets. However, many CIPs failed to explicitly address climate change and, when present, climate change is not adequately integrated. Statistics below shows the priority areas where GAFSP funding has been applied (Table 6.1).

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

Country	Year of accessing GAFSP funding	Amount obtained (US $)	Priority areas
Rwanda	2010	50m	Implement hillside irrigation.
Ethiopia	2010	51.5m	Strengthen advisory services and improve small-scale infrastructure.
Malawi	2012	39.6m	Promote irrigated rice and horticulture production.
Burundi	2012	30m	Improve water mgt and irrigation in drought prone.
Zambia	2013	31.1m	Improve food production; develop value chains and capacity building.
Uganda	2013	27.6m	Support linking agriculture, nutrition, health and education.

The growing realization of the negative repercussions of climate variability and change on rural livelihoods has led to increased focus on climate and agriculture in Africa. The United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) and negotiations between governments are ideal for countries to strengthen the climate and natural resources management components of their CAADP programmes in a systematic manner.

6.3 Climate Smart Agriculture Alliance as an Investment Opportunity

The NEPAD through the Comprehensive African Agricultural Development Program (CAADP) has launched an alliance of diverse partners (including CARE, Catholic Relief Services (CRS), Concern Worldwide, Oxfam and World Vision) with the aim of reaching 25 million farming families through Climate-Smart Agriculture and become more resilient and food secure by 2025. The alliance will develop a road map to stimulate the uptake of CSA practices focusing on the vulnerable rural communities.

A major concern in this effort is as to how to coordinate and facilitate the scaling up of on-farm assistance, linkage to technological advances and support to a favourable policy environment for implementation of CSA that is needed to bring a lasting transformation of farmers. Members of the alliance will work collaboratively to design and implement programmes in a way which maximizes 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 to drive policy reform. This will be achieved through aligning international non-governmental organisations (INGOs) and research activities across Africa with the existing national agricultural investment plans, increasing coherence and coordination towards adoption of CSA strategies by the targeted number of farmers.

6.4 National Agriculture Food Security and Investment Plans

As part of their compacts with CAADP, some African countries have developed NAFSIPs alternatively referred to as NAIPs, all of which are currently being implemented. The NAFSIPs of Burkina Faso, Senegal and Sierra Leone are the National Programme for Food Security (PNSR) 2011-2015, the National Agricultural Investment Plan (PNIA) 2011-2015 and the Smallholder Commercialization Programme (SCP) 2010-2014 respectively. Loada (2014) outlined the evolution of Burkina Faso's NAFSIP and pointed out its coherence with CAADP principles.

Analysis of these national agricultural investment plans for climate smartness has been done on the basis of potential contribution to adaptation and mitigation, production and productivity improvement, value chain enhancement, institutional support and consistency with NAPAs (Branca, 2012). Like for the NAPA's the level of participatory development and coordination and gender were also part of the analytical framework.

6.5 Investment Opportunities for Implementing CSA in Africa

There are many opportunities worthy of consideration. At the governmental, regional and continental level, 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 NAREs and 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 out. Frameworks for implementing NAFSIPs and PRSPs are well set up and in line with government policies of decentralization of certain functions to district levels could be exploited for CSA.

Specific opportunities include; Existing knowledge and experience with CSA e.g., CCAFS Climate Smart Villages in Senegal and Burkina Faso; existence of frameworks e.g., FAO (2012) on climate change and gender mainstreaming to guide governments and practitioners of CSA. Community level approaches to adapt to climate change developed by ENDA (Ampomah and Devisscher, 2013), tools on integrating gender into CSA (BNRC, 2011) and availability of Best Bets.

It is well known that adequate and sustained financing is fundamental for CSA to be widely adopted by small scale farmers. The survey of Burkina Faso, Senegal and Sierra Leone clearly demonstrates major gaps in funding of NAFSIPs even when they do not explicitly tackle CSA per se. The CAADP framework provides guidance on sustainable financing and is therefore an opportunity worth exploiting. CAADP (2010) outlines these as follows: developing, adapting and providing to country and regional initiatives instruments and capacity development support to engage and negotiate at global level for financing African Agriculture from sources covering broader climate change objectives; targeting and facilitating direct engagement and access to (i) bilateral and multilateral development aid(ii)direct foreign investments and local private financing and (iii) special instruments for public-private co-financing arrangements; providing 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 (GEF)'s move towards combining mitigation and adaptation in the GEF-6CCM) (FAO, 2013) should facilitate funding of CSA.

There are national farmers associations and regional farmer's association (ROPPA) playing advocacy roles for farmers. At the community level, there is social capital in the form of Community and Farmer Based Organizations. The social capital in rural communities which brings rural folk together to alleviate labour shortage at critical periods in the farming calendar and in reacting to natural disasters are also opportunities for CSA. Many farmers (producers) are now aware of their vulnerability to the effects of climate change and are already adapting by having increased collaboration and partnerships.

Incentive systems for implementing CSA

African governments have often provided price support to farmers channelled through subsidies of inputs such as fertilizers (examples are Malawi and Kenya); in Malawi the subsidy resulted in significant transformation in the agricultural sector through increasing the rate of adoption of fertilizers and improved maize production. Subsidies could be channelled 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 agroforestry, land management, fodder production and soil conservation require long term investments for success. Secure land tenure enables farmers to make thses long term investments and increases their willingness to invest more money in the farm. There is need to support secure land tenure in all agricultural lands in Africa to provide property rights to farmers which would in turn provide incentives for long term investment and engagement with markets.

Enabling Farming systems

Most farms in Eastern and Southern Africa comprise an *ad hoc* complex mix of crops, livestock and trees that interact, often interdependently such as maize providing forage for livestock (where the alternative is to burn crop debris after harvest). Each of the farming systems have a perspective of 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 inhibitive to poor households because investing in new practices requires labour and incurs costs that must be borne before the benefits can be reaped. Pairing short-term with long-term practices may overcome some of the timing constraints. Payments for carbon sequestration may be an appropriate way of covering the time lag between investing in climate-smart practices and obtaining the environmental and economic benefits. Currently only Plan Vivo provide 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 risk to farmers so as to overcome these investment gaps.

Providing an enabling legal and political environment

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

Developing the marketing and information infrastructure is vital to farmers. 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. Drivers, Challenges/ Constraints

7.1 Drivers for Promoting CSA in Africa

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. Spontaneous spread of innovations occurs almost exclusively through farmer-to-farmer information exchange (Liniger and Critchley, 2007) yet adoption of CSA in Africa is still very low. Just like in other parts of the world, climate change has been misunderstood to mean a variety of problems affecting farmers. Awareness about climate change in developing countries is still low compared to the developed world, with African countries rated as the least aware Tables 7.1 (Pelham 2009).

In some cases, African farmers have been found to have a problem in differentiating between impacts arising from climate change and problems caused by local environmental degradation (Mutimba, et al., 2010). A participatory rural appraisal meeting involving climate change experts that took place in Kenya noted that across Africa, all problems related to decreasing crop yields afflicting farmers are blamed on climate.

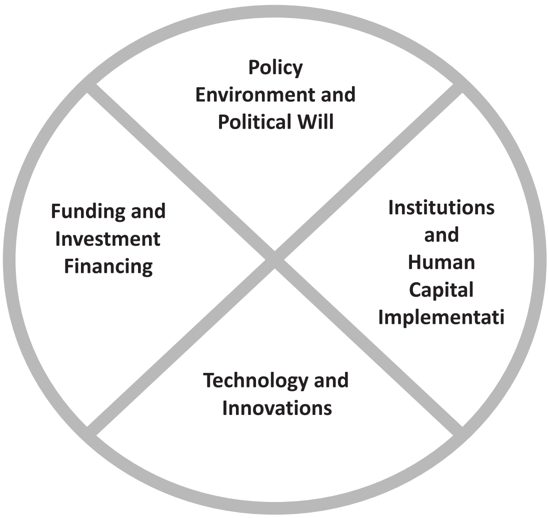
Using data from Ethiopian households, Temesgen, et al., (2008) noted that a number of factors such as age of the household head, wealth, information on climate change, social capital, and agro-ecological settings influence farmers perception and hence adaptation to climate change.

Indeed, across Africa, 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).

The important socio-economic characteristics vary across Africa, but overall, a depressing reality about the nature of African agriculture is painted. Many farmers are about 55 years of age or over, mainly illiterate, with women being most disadvantaged. African farmers are working under harsh biophysical conditions compounded by climate variability and change and are faced with 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.

Table 7.1 Farmers perception on climate change impacts across selected countries in Africa (as percentage agreeing)

	Tanzania (Swai, et al., 2012)	Rwanda Choise 2013)	Zambia (Kalinda 2011)
Existence of climate change	53	80	27
Human activities as a cause of CC	15	75	43
Drought	99.45	23	46.37
Floods	-	7	54.72
Soil erosion	-	8	-
Hotter temperatures	97.75	12	41.79
Unpredictable rains	81.95	11	80.53
Domestic animal decline	-	5	-
Stronger winds	96.4	-	-



Source: NEPAD 2010

Figure 7.1 Drivers supporting the CAADP framework

Figure 7.1 below provides a summary schematic representation of drivers of CSA in Africa. These are policy environment and the political will, funding, institutions including the critical human capital to provide labour and the technologies and innovations provided by R&D.

7.2 Institutional Human Capital and Technical Innovations

Hard economic circumstances were common among African farmers with about 50% of the population living below a dollar a day resulting mainly from the high-rate of population growth of about 3% across Africa that puts a lot of pressure on land and limits the households capacity to meet their needs. Population pressure on the land is worsened because people lack access to alternative sources of livelihood with agriculture employing about 80% of the population. Deforestation and use of dung and crop residues as energy sources are increased by people's inability to afford or lack of access to alternative fuel sources which adversely affect efforts towards CSA.

The low literacy levels limit farmers' capacity to access information associated with CSA. Improving access to information through development of easy to comprehend CSA information packages on development and implementation of CSA technologies, through improved research and extension service will promote CSA. As indicated earlier, climate change is not well understood across Africa. Perceptions of climate change vary according to country which is an indication of differences in the effectiveness of information availability and dissemination across countries and the agro-ecological zones. In areas of high production potential (e.g., in Rwanda in the Humid AEZ) and partly controlled agricultural production environments (e.g., in Zambia) less than 30% of the farmers thought that there was climate change in their areas. In countries like Ethiopia where the production systems were mainly rain-fed and farmers were very vulnerable because of poverty and perception of the existence of climate change was 80%.

The increase in the rate at which natural resources are degraded across Africa has raised concerns among many development partners and governments for adoption of more environmentally friendly techniques. Most of the initiatives to reduce the toss of natural resources come in the form of incentives, policies and institutions that support environmentally friendly production systems such as climate smart agriculture.

Africa is characterized by many countries in the region investing billions of dollars in education. The outcome is a more educated society with a potential to readily adopt new innovations. In the technology sector, there is an increase of options in which information can be relayed faster and more accurately. Such developments favour adoption of CSA in the region. Although Best Bet technologies on CSA are available, there isa dearth of scientific information at the local level. Strategic and applied research is required for the development of sustainable CSA

7.3 Funding and investment financing for CSA

There are a number of actors already working on aspects of CSA across Africa. These actors work in diverse ways contributing to the improvement of the welfare of communities and providing a variety of entry points for CSA. The institutions are important in bridging the financial and technical gaps for developing CSA programmes in Africa.

The actors can be categorized as follows;
Global: Development partners (Donors, INGOs, UN, CGIAR, Philanthropists, etc.)
Regional: FARA, NEPAD, ACPC, PAFO, GGDG, PanAAC,
Sub-regional: SRO, COMESA, SADC, RECS, CILSS, RUPA, SACAA, Basin Authorities
National: NARS, NARIs, Ministries, Universities, Polytechniques, Farmer organizations, NGO, CBO, FBO, Non-state actors
Local: Local authorities, villages, farmer organizations, NGOs, Extension, CSO, Specialized groups (women, youth, men)

The actors provides entry points for practicing CSA in Africa through supporting institutions, providing funding, and involving themselves in discussions that drive the CSA agenda.

7.4 Institutions, Policies and political will

Climate-smart agriculture requires changes in farming households' strategies for producing food and fibre. Without appropriate institutional and policy structures in place, CSA innovations may seem overwhelming to smallholders. In the African region, there are a wide range of institutions that support farmers in training, linkages with markets and in carrying out the diverse activities in the farm. These institutions play a critical role in relaying of accurate and timely information, building farmers financial and production capacity and providing a wide range of support to farmers. Some of the notable farmer institutions include farmer cooperatives, international NGOs and women groups association. Institutions can support smallholders in three vital areas:

- Producing and sharing technical knowledge, from the perspective of a relatively resource-poor smallholder.
- Providing financial services (including credit) and access to markets, and
- Supporting the coordination of collective actions.

Collective action is critical for managing communal forests and pastures and lowering transactions costs. Many CSA activities are only feasible and affordable if people work together (e.g., improved water or rangeland management), so institutional arrangements that make groups function efficiently and effectively are key.

Institutional factors can influence adoption of CSA through their impacts on farmers' decisions regarding land use and land management practices. A non-exhaustive list of such factors influencing these decisions includes population pressure, poverty, land tenure relationships, the nature of local markets, local institutions and organizations, and farmers' perceptions and attitudes. Data obtained from PRA involving experts of climate change showed that CSA technologies require a set of legal and structural arrangements in order to be adopted. The key variables are land tenure security, access to information, availability of credit and avenues to meet the cost of transaction.

Across Africa, lack of tenure security and limited property rights, may hinder 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 the eastern Africa region, less than 30% of the households had secure land tenure systems and those with land titles were even fewer in West Africa. Comparing the security

> Many people equate 'institutions' with 'organizations'. In reality, institutions signify something broader than organizations. They essentially define the 'rules of the game' – the way things are and can be done, as defined by accepted norms, roles and values. Institutions include formal organizations and contracts as well as informal social and cultural norms and conventions that operate within and between organizations (North 1990; Ostrom 2005).

of land tenure in different farming systems, pastoral communities were the worst without secure land tenure systems. Unsecure land-tenure is a major hindrance to adoption of CSA that limit farmer's capacity to make long term investment decisions. Communal land tenure systems were common in the arid and semi-arid AEZ. Tables 7.2 and 7.3 shows the influence of the various variables on CSA. It can be inferred from the benchmark in the sample countries that there exists opportunities for interventions which promote CSAs through addressing the socio-economic and structural constraints. Although education levels of African farmers are low, 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 7.2 Impact of different variables in the adoption of CSA

Variable (Drivers)	Impacts on adoption of CSA (Direction of influence)	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 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
<u>Socio-economic characteristics</u>		
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 Labour force	+/-	CSA technologies can either be labour saving, labour using or neutral.
Farmer extension support and general human capital	+	Technical advice to farmers simplifies complexity is some technologies and increases technology adoption

Source: FARA Field survey (2014)

Table 7.3 Summary of factors that promote/hinder CSA

Variable	Influence
Socio-economic variable particularly the economic resources	Greater economic resources increase adaptive capacity of farmers 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.
Infrastructure	Greater variety of infrastructure can enhance adoption of CSA. These include communication and market infrastructure. Lack of skills by the farming communities reduces their adaptive capacity
Institutions	Well-developed social institutions help to increase flow of information, technologies and farmer support for promotion of CSA 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.

7.5 Challenges/Constraints in Implementing CSA

Land tenure systems in Africa

In most countries in Africa, men 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 major decisions including long term investments. Implementing CSA programmes that incorporate long terms investment requires their commitment and 'buy in'. On the other hand, women have greater authority over food production and may supply up to 80% of the labour required in the household to produce food. Women are also more likely to interact well with extension staff and other agencies that promote CSA compared to their male counterparts. Unclear land tenure may lead to difficulties in establishing benefit distribution mechanisms for payments for ecosystem services (Runsten and Tapio-Bistrom, 2011). There is need to address the land tenure issue to ensure that women's rights to land and long term investments in households are recognized and empowered.

Proposed changes should be adapted to a country's particular tenure systems to minimize conflicts with culture, tradition and competing uses. There is no country with a comprehensive land tenure system that satisfies the needs of all stakeholders although countries such as Kenya, Zambia and Zimbabwe have to a large extent secure land tenure systems. But even in these countries, there are vast areas with no secure land tenure systems with the potential of embracing CSA technologies. In all the countries and AEZs in Africa, even without secure land tenure systems, there is a potential for contracting with farmers use of land on long term basis as in the case of Ethiopia where local authorities facilitated simple registration of land to allow for investment in sustainable land management systems.

Market failure resulting from poor access to information and markets

Realizing the potential of CSA depends on the ability to convey market information, coordinate production and marketing, define and enforce property rights, and mobilize farmers to participate in markets and enhance the competitiveness of agro-enterprises (FAO, 2012b). Implementing CSA requires a marketing system that conveys timely and accurate information on production and marketing information for the environmental services generated or to be generated. In the rural communities, there are no structures to convey such information particularly on markets for environmental services (ES) and while ES markets are poorly developed. Communities find it difficult to package ES generated in a way that can be offered in a market. Thus, the issue is that because of lack of the institutions to convey the information and lack of proper marketing mechanisms there is generally market failure and the forces of demand and supply of ES services do not work.

Poor business development services

Farmers in the Africa can best be described as being risk averse and preferring not to use credit for their 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 financial products suitable for them. On the other hand, the product market is highly volatile with prices being unpredictable and farmers are in a non-structured marketing system. There is need to improve the overall agribusiness environment through simple, transparent regulations, tax structures and finance regulations in order to attract more investment in the sector.

Institutional and Socioeconomic Challenges

Government ministries work more or less independently and food security is perceived as mainly the responsibility of one ministry (Ministry of Agriculture), when food security by definition implies involvement of a range of government ministries. Governments for example that of Sierra Leone have found it difficult to satisfactorily carry out land reforms.

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’, involving planting of trees, making soil and water structures expected to last for several years. For example where inheritance of land is patrilineal, decisions are made by the head of families on allocation of land for annual cropping , and women and strangers can have access to land even though women provide a very large part of the agricultural labour force. However, tenants (strangers) are excluded from planting of perennial crops or trees because planting trees indicates long term interest and investment in the land meaning that the planter owns the land. Rural to urban migration by youth contributes to labour shortage at critical periods and this impacts most seriously on the adoption of soil and water technology high in initial labour demands e.g. stone bunds and zai.

Research/Technology Transfer

Research on how to mitigate the impacts of climate change and variability to agricultural productivity is still very limited in Africa (Antai, et al., 2012). There is inadequate knowledge of how technical CSA practices will perform in specific locations; appropriateness and profitability of technologies; little or no knowledge of how trade will be affected by climate change; current GCMs sometimes give conflicting predictions of impacts on crop yields; inadequate knowledge of risk management in terms of insurance in some countries; limited understanding of landscape approaches in achieving CSA (the numerous tiny farm holdings for crop farming do not facilitate this); limited or no involvement of policy makers in the research process; ineffective forms of communicating research results to policy makers and end users.

Finance

The initial investments in CSA are generally high while the benefits may not be immediate. Governments are constrained to provide the required funding even for their NAFSIPs, PRSPs and institutions responsible for data collection and research. The bulk of funding required for key programmes is from external sources. Incorporating CSA would require additional funds, which national governments do not do.

Agricultural Policies, Plans and Programmes

Mitigation benefits associated with adaptation options are not recognized in national agricultural development and investment plans. Apart from 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 provision of subsidies in the agricultural sector and governments have resorted to food for work and reduction of duties on imported agricultural inputs as incentives. How effective these are is uncertain. The following are broad challenges that more or less cut across the countries surveyed and CSA practices (Table 7.4).

Table 7.4 Summary of Challenges to 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 partners contributions to these
How to manage complexity, where everybody wants 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 put emphasis 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 assessed in participating CSA organizations. Develop activities to fill these gaps (training, recruitment, build infrastructure etc.).
Different M&E approaches language and terminology.	Come up with appropriate Alliance definitions/ terminology and be consistent, Under take a harmonization approach. Enable organizations map their own terminologies.
Language – mostly a challenge for learning systems at a farmer level.	This will be complex but can be handled at local levels. National and regional levels are usually in English and French.
Counting the 25 million farmers will be challenging due to: - definition of CSA adoption/ partial adoption - new vs. old farmers adopting CSA	PMF and Indicator definition activities will inform this.
Organization of ministries – ministerial collaboration	Engage high level from the beginning
Poor & unstructured markets	Contracts, market & value chains
Risk (production, enterprise)	
Lack of government money & financial Commitment	Regional agreements

Source: Lineger, et al., (2011)

Plate 7.1 Best Bets for CSA needs good examples and transfer of knowledge

8. Creating CSA Enabling Environments and Stimulating Climate Smart Agriculture

8.1 Encouraging Farmers to Adopt Climate-Smart Practices

Given the risks that are involved in farming, farmers need to be encouraged to adopt CSA. This can only done if there is an enabling and empowering environment.

This needs the building of synergy between NAIPs/NAFSIPs and national climate change instruments, particularly NAPAs/NAPs and NAMA. Some actions include;

i) Population increase that puts pressure on government to provide food for all.
ii) The increase in the number of unemployed youth and thus the need to make agriculture attractive to them.
iii) International requirements to reduce agricultural emissions without compromising productivity.
iv) Emerging new institutions arising from recommendation in international forums
v) Enabling policy environments
vi) Diversified sources of finances to support climate smart agriculture

The priority for small-scale farmers in Africa is to reduce the impacts of climate variablility and change and increase their production. Mitigation is often a positive non-intended outcome. Where appropriate, policymakers should encourage such projects such as Climate Smart Villages to operate and farmers to reap the benefits of adopting CSA.

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 following the World Bank's 'Adoption of Sustainable Agricultural Land Management' methodology, which uses land management practices as a proxy for carbon stock changes. The project is operating in Western Kenya, which are dominated by subsistence farms with an average of less than one hectare of highly degraded land. Implemented by Vi Agroforestry, a Swedish non-governmental organization, the project is helping these farmers adopt sustainable agricultural land management (SALM) practices, such as reduced tillage, use of cover crops and green manure, mulching, targeted application of fertilisers and agroforestry.

Under the Vi Agro Project, conservation agriculture, which involves the use of minimum tillage, the retention of organic matter and crop rotation, help farmers reduce their carbon emissions, increase crop yields and cope with climatic variability. Agroforestry, which involves planting trees on farmland, can sequester carbon, improve soil fertility, reduce soil erosion, provide alternate pasture and raise smallholders' incomes. Farmers are encouraged to adopt these technologies if they are educated to see the income benefits and the reduction in climate change risks associated with the adoption of climate-smart practices.

Adopting a Multi-Sectoral Approach to Policy Making

Increasing 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 wise resource allocation and action by a wide range of government ministries, including those with responsibility for agriculture, rural development, research, gender, environment, trade, education and transport.

Creating the Financial Incentives for Climate-Smart Agriculture

Successful CSA strategies (See Appendix 4) will require investment in infrastructure that can support smallholder farmers in understanding climate change, developing and refining strategies and evaluating CSA options. Some researchers have recommended establishment of transition funds to be used to compensate farmers during the periods between the establishment of CSA structures such as agroforestry practices and the time positive impacts of agroforestry are felt by the farmers.

CSA provides an opportunity for farmers also to benefit from additional funds through Payment for Environmental Services (PES) schemes. But development of PES programmes is beyond farmer's financing capacity and a special fund could enable farmers benefit from such PES schemes leading to higher adoption of CSA practices.

Developing Effective Research

The general present state of agricultural research in Africa especially in the NARIs and universities is characterized by dilapidated, overburdened facilities and often with few women on staff. There are limited systems for data sharing and often research learning platforms have few CSA learning areas. The research agenda for a research institution or scientists is often determined by a wide range of factors including the supplier of the research funds. Developing a research scheme with funds locked to CSA studies will ensure that the 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 also in international negotiation forums. There is need to lobby governments to consider CSA as a vital intervention measure to improve farmer incomes, food and nutrition security.

8.2 Gender Considerations in 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 the fact that land tenure systems and availability of funds to invest in better technologies are socially differentiated by gender. Because of this, women and men have differences in responding to climate change and in taking up opportunities presented by CSA. Through understanding of how climate change will 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 in order to increase adoption of CSA.

Evidence from Africa is that men and women do not benefit equitably from climate change adaptation programmes; which are often targeted at men than women because the men are responsible for growing cereals (staples), even though the entire family works on the farm. Many of these programmes involve reforestation, soil and water conservation and use of organic manures. Adaptation programmes for women focus on diversification of income generating activities, including vegetable production, poultry farming and home gardens to offset losses in cereal production. Although these programmes are welcomed by women they do not deal with their strategic interests in terms of access and control over assets and decision making power. Failure to take gender into account may result in increasing work load of women.

Some examples in Africa of the relationship between gender roles and adaptation are: men improving access to water by using donkey - driven carts, to facilitate collection of large quantities of water and storage in casks, when water sources are far away from dwellings. NGOs in Senegal have provided assistance to women in constructing 'half-moons', which control soil erosion and thereby retain water, rehabilitate land and improve agricultural yields. Men and youth migrate and women are left to fend for themselves e.g. in the village of Landou in Senegal there are 118 women and only 20 men (WEDO,2008) as a consequence of climate change. Nielson and Reenberg (2010) reported, culture was a barrier to adaptation in the form of women engaging in economic activities and other livelihood activities. Conservation agriculture involving minimum tillage may reduce labour requirements for land preparation (normally the responsibility of men), but weed control without use of herbicides may lead to more labour requirement for weeding a task that is usually done by women (Giller, et al., 2009).

In Chololo Eco Village, Tanzania participation of women in training programmes is determined by cultural norms and roles and the topic of the training. Women tend to be left out of events involving agricultural technology transfer because they stay at home to attend to children, and elderly and ill relatives (Annecke and Koelle, 2011; Kalumanga, et al., 2014). The Level of female participation goes up when training involves income generating activities. In Cameroon, women have been keen to get involved in tree planting programmes but only when they are educated about the project input and outcome before the start of the project (Njodzeka, 2011).

8.3 Priority Crops and Livestock for CSA Practices across Africa

Research and development work has so far involved a limited number of crops but this should not be interpreted to mean that they are the only "crops suitable for CSA". There are overlaps in the distribution of crops and livestock across the agro climatic zones and the distribution will change further as rainfall, temperature and length of growing period change.

Millet is the major food crop in the semi-arid zone; other crops of importance are sorghum, cowpea, groundnut, cotton and vegetables. Cattle are the major livestock but small ruminants (sheep and goats) and poultry are also found. In the sub-humid zone, sorghum, rice, maize, groundnut, cowpea, sweet potato, potato, cotton, vegetables are important. The same livestock that are found in the semi-arid zone are also raised. The major crops in the humid zone are rice, maize, beans, vegetables, cassava, sweet potato, yams, cocoa, coffee, oil palm, rubber, but sorghum, groundnut and cowpea are also grown in the drier parts. Sheep, goats and poultry production is widespread. Cattle are raised in the drier areas of the zone but cattle production is of much less importance compared to the semi-arid and sub-humid zones. Pigs are raised, and local breeds of livestock are more tolerant to heat stress and drought compared to exotic breeds though much more research has been done on the effects of climate change on crops than livestock, there is some evidence that coat colour of small ruminants may be a contributing factor to tolerance to heat (Fadare, et al., 2012).

9. Conclusions and Recommendations

A range of stakeholders working in a coordinated fashion is required for successful CSA. They include extension services of governments and NGOs, national research institutions, CGIAR, regional and continental research and development organizations and economic and political bodies (FARA, CORAF, ECOWAS, AU), private sector, community and farmer based organizations and individual farmers. The role of donor organizations is crucial for success.

9.1 Variables/Drivers that promote/hinder the Adoption of Climate Smart Agriculture

The drivers for scaling CSA up and out 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 elaborating 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.

Recommendations

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

9.2 Successful Climate Smart Agricultural Practices for Scaling Up and Out

CSA in its true comprehensive form is not yet being implemented within governments and among farmer's in Africa. Many of the CSA technologies are designed first to increase production rather than protecting the natural resource base. This approach has implications on long term sustainability.

Recommendation

To promote true CSA, 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, as appropriate. Besides the technological options, climate risk management techniques such as seasonal weather forecasting, index-based insurance and safety nets should be used. The community- based participatory climate smart village approach involving climate risk management should also be encouraged.

9.3 Policies that Promote Climate Smart Agriculture

In the twelve countries used for the study, there were no specific policies promoting CSA at national, sub-regional, and regional levels. National Food Security and Investment Plans all have elements of CSA but they 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 as mechanisms for harmonising policies.

Recommendation

Enabling policy environments for CSA to thrive should be a priority by governments through (i) recognition and accommodation of multiple objectives of increased food security, adaptation to climate change and reduction of GHG emissions (ii) creation of incentives (iii) alignment of CSA with good economic, health, social, infrastructural and environmental sectoral policies and programmes so that they are mutually supportive (iv) support for data collection and analysis to identify which strategies will best lead to sustainable food security, adaptation, and mitigation benefits (v) mainstreaming of CSA into NAFSIPs and overall agricultural strategies (vi) improved land tenure security, taking special considerations of the needs of vulnerable groups like women and youth (vii) improved access to information and knowledge from institutions that generate knowledge; promote climate risk management(insurance, weather forecasting, social safety nets). To cope with risks associated with climate change and adopting new practices. CSA should be mainstreamed into national policies and programmes. There is need to step up dialogue with national governments to streamline CSA in government programmes, policies and institutions. FARA can drive this agenda and achieve coordinated efforts towards CSA.

9.4 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. There are also few climate models dealing with livestock and even less deal with projected heat or water stress effects on farm animals. In addition, integration of adaptation and mitigation into policy and practice as well as mainstreaming of climate change issues into agricultural development and planning are lacking. There are financial gaps because governments are unable to fund their NAFSIPs.

Recommendations

It is recommended that the following be done by practitioners of CSA (researchers, development workers and organizations): address gaps dealing with crop and livestock research and development as priorities; identify types of support needed most by stakeholders; capacity building efforts should include workshops and study tours for national research and extension staff and policy makers. Adopt farmer-based participatory experimentation as well as complementation of indigenous knowledge with scientific know-how. AU -NEPAD should strengthen its support to governments to enable them access funds from existing and new sources. Governments should improve funding for national research institutes, universities and ministries of agriculture.

Communities should organize self-help schemes. The private sector should get involved e.g., the lottery companies, commercial banks, exporters and importers of food should all contribute to CSA. Assistance from philanthropic foundations should be sought. Communities should contribute by embarking upon self-help schemes but they will have to be convinced of the benefits accruing from CSA. All of the above needs to be done in a gender sensitive way.

9.5 Challenges and Opportunities affecting Climate Smart Practices

All the countries in the survey had challenges in terms of inadequate policy, institutions, research/technology transfer and funding. The awareness at the community, national, regional and international levels of the negative impacts of climate change and the need to respond adequately should be seen as opportunities for CSA.

Recommendations

Incentives such as food for work, fertilizer voucher schemes, access to credit and markets should be provided by governments and NGOs to farmers. Farmers should be provided assistance by government and NGO's to strengthen farmer and community groups. Governments should provide weather forecasts in easily useable forms and through suitable media, including radio networks accessible by rural communities. The capacity of national institutions working with community-based organizations and farmer based organizations to innovate and develop community action plans, preferably on a landscape (micro-catchment) basis should be strengthened. NARES should develop strong linkages with AU-CAADP, ECOWAS, FARA and CORAF, and CGIAR centres.

9.6 Priority Crops and Livestock for CSA Practices in Africa

Various crop species are impacted by climate variability and change to different degrees. The current situation is that positive responses to CSA have so far been reported for crops such as millet, sorghum, groundnut, rice, maize which are all important food and cash crops across Africa.

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

Recommendations

Drought tolerant crop species and varieties should replace less drought tolerant ones in areas where rainfall is predicted to decline and the opposite where rainfall may increase. Also, it is desirable to develop varieties with some tolerance to salinity, flooding, and are responsive to integrated soil fertility management.

Information sharing across regions provides rapid ways in which technologies can be promoted. More attention needs to be given to improving the 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 will result in breeds of cattle and small ruminants combining hardiness with productivity should be strengthened.

9.7 Gender Considerations

Women in rural communities of all countries are particularly vulnerable to climate change because they are disadvantaged. Gender is being taken into account in developing responses to climate change, but the efforts do not go far enough.

Governments need to mainstream gender into development and climate change policies and programmes. Laws that promote and improve women's access to land and land ownership need to be passed. As well as access to land, women need agricultural extension services, credit and farm inputs. This should be done in the context of Climate Smart Agriculture and linked to access for women farmers to climate and weather information.

Targeted and gender sensitive awareness raising programmes are needed on CSA in communities, those involved in national development at all levels as well as women's organisations. This will help promote active participation of women in decision making.

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11. APPENDICES

APPENDIX 1: 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

APPENDIX 2: List of Contacted Persons

Professor Eric Eboh	Agricultural Policy Research Network, Abuja
Mr Nathan Phiri,	ARI, Zambia
Dr Leopold Some,	Burkina Faso
Mrs Fanta Diallo,	Burkina Faso
Wilfred Awung	Cameroon
Mr Andrew Katta,	CARE, Sierra Leone
Caroline Mwongera	CIAT, Nairobi
Zagabe Jasperr	CNJCC, DCR
Dr Abdulai Jalloh	CORAF, Senegal
Mrs Farma Ndiaye,	CORAF, Senegal
Peter Tarfa	Department of Climate Change, Federal Ministry of Environment, Abuja
Dr Ibrahima,	Diedhiou, National School of Agriculture. University of Thies, Senegal
Dixon Okoro	Federal Ministry of Agriculture Abuja, Nigeria
Dr FrancoisLompo,	INERA, Burkina Faso
Eddah Kaguthi	KARLO, Kenya
Elizabeth Okwousa	KARLO, Kenya
Jane Wamuongo	KARLO, Kenya
Keziah Ndungo	KARLO, Kenya
Mary Kifuko	KARLO, Kenya
Michael Okoti	KARLO, Kenya
Daniel Omondi	KCCS
Mr Olu John	President National Farmers Federation of Sierra Leone
Mr Prince Kamara,	Programme Manager, Smallholder Commercialization Programme, Sierra Leone
Didas Kimaro	Tanzania
Francis Mwaura	Uganda Policy Research Organization
Prof Berhanu F Alemaw	University of Botswana
Diffang Funge	University of Dschang
Rebecca Mbinge	University of Eldoret
Dr Mangani Katundu	University of Malawi, Chancellor College
Benson Mwaura	University of Nairobi

APPENDIX 3: Survey Instruments(Tools)

Task 1a: Analyse/Assess farmers' understanding about climate change and CSA(from key informants) FARMING SYSTEMS

WHAT IS CLIMATE CHANGE		VULNERABILITY TO IMPACT	WHAT ADAPTATION STRATEGIES ARE USED	WHAT CSA PRACTICES ARE RECOMMENDED/IN USE
Climate Change Hazards	Climate Change Impacts/ What are the impacts of climate change on livelihoods			
List and Prioritize (most important first) the major changes in the environment that have been observed (e.g. drought, floods, windstorms, no change, etc) in the target AEZ in your country	List and Prioritize (list most important first) how these changes have affected agriculture in the target AEZ in your country (e.g. crop failure, reduced yield, reduced livestock numbers, fodder shortage, deforestation, loss of biodiversity (animals, plants), heat stress, etc	List what make the target AEZ in your country vulnerable (e.g poverty, out-migration by men or youth, illiteracy, lack of access to resources, clinics, extension services, etc). Be gender specific where possible.	List and prioritize (list most important first) traditional and new strategies that have been identified in the target AEZ in your country. State differences in men and women use of these. Please put in brackets resources required for each strategy.	List and prioritize (list most important first) CSA practices in the target AEZ in your country (drought-resistant varieties, early maturing crops, changes in cropping calendar, cattle manure management etc. State any gender specific measures in use.
Sources of references (please provide a list of recommended references to support data provided in each of the items				
If you can, please comment (on an additional page) on any related issues, that will be appreciated				

Task 1b: Categorizing/Profiling of farmers Categorize farmers in (i) traditional ways of age, education, sex, wealth, income; (ii) social capital, human capital, natural capital, institutional capital etc. (iii) small scale vs large scale –scale of operation

Categorizing/Profiling of farmers Categorize farmers		
	Responses	**Provide references to support each of the information provided**
(i) traditional ways of age, education, sex, wealth, income;		
(ii) social capital, human capital, natural capital, institutional capital etc.		
(iii) small scale vs large scale –scale of operation		

Task 1c/1d: Identification of farmers coping, adaptation, and mitigation strategies and which ones are currently in use

Climate Change Hazards	**Climate Change Impacts/What are the impacts of climate change on livelihoods**	**ADAPTATION STRATEGIES IN USE**	**MITIGATION MEASURES IN USE**
Specify form of hazard	Specify impact on agriculture/ livelihood	Specify changes in response to hazard and impact	Specify any carbon emission reduction impact of each measure t
Sources of references (please provide a list of recommended references to support data provided in each of the items)			
If you can, please comment (on an additional page) on any related issues, that will be appreciated			

Task 1e: Document CSA technologies available in Africa (document technologies as productivity, mitigation and resilience)

	Climate Smart Agricultural practices existing in Africa (specify where in Africa)	
Productivity impacts		
Mitigation impacts		
Implications for resilience and how		

Task 1f:Success indicators for recommending CSA Technologies

Climate Smart Agricultural practices in use (specify)	Productivity impacts (incremental yield; return to labour, capital)	Mitigation impacts (Reduction in carbon emission)	Resilience implications (increase in incomes, decreasing dependence on weather)	Recommendations
Sources of references (please provide a list of recommended references to support data provided in each of the items)				

Task 2a: Identify countries with policies related to CSA

	Country and Nature/title of policies	**Sate of implementation and time frame**	**Specific CSA components in each policy**
Policies related to UNFCC; National communication on climate change			
i) National policies on climate change			
ii) policies on adaptation National Adaptation Strategy and Plan of Action on Climate change			
iii) National Appropriate Mitigation Actions (NAMA)			
iv) Agricultural strategies and country investment plans			
v) National environmental policies (biodiversity, water, forestry etc)			
vi) Regional policies on agriculture/ Environment			

Task 2b: Review and analyse policies in context of CSA

Nature/title of policies	Identify elements of CSA in policies	Link policy elements to resource allocated in national budgets	Link elements to allocation of responsibilities

Task 2c: Attributing CSA practices to policy

Nature/title of policies	Identify elements of CSA in policies	Assessment of existing policies, programs/projects that promote elements of CSA (Extent, impact, and constraints to implementation)	Use information above to recommend to similar Agro-ecological zones (AEZ) with similar socioeconomic characteristics (specify elements of CSA, recommended, AEZ and socio-economic characteristics)

Task 3: Assess future climate scenarios and relate to CSA interventions, market and financial needs

1.

Specify climate parameter of interest (Temperature, precipitation, extreme climate/ weather events, etc)	Characterise in specific period in the past (25, 50, 75, 100 years)	Current situation	Characterise in specific period in the future (25, 50, 75, 100 years)	Implications for specific CSA interventions in specified periods	Implications for market needs	Implications for financial needs	Identify CSA policy needs required to address future climate scenarios

Task 4: Identify existing gaps and investment opportunities where CSA can intervene within the CAADP framework

Describe CAADP framework in relation to CSA (policy, research, technology, finance, market, etc.)	Identify what needs to be done in each of the gaps identified

Task 5: Determine the drivers, challenges/constraints and opportunities that may facilitate or hinder scaling up and scaling out CSA practices in Africa

Drivers, challenges/constraints, and opportunities	Assessment	Sources of references (please provide a list of recommended references to support data provided in each of the items
Policies		
Institutions		
National strategies/ priorities		
Resources		
Capacities (HR)		
Government framework		
socio-economic parameters		
Others (Specify)		

APPENDIX 4: Successful CSA Practices

	CSA Practice	Result
Burkina Faso	Stone bunds/zai pits along contours Farmer assisted natural regeneration tree (*Faidherbia albida* or *Piliostigma reticulatum*) stumps to regenerate and leave the cut leaves on the soil surface.	• Increase of sorghum and millet yields of up to 1t/hectare (100%) over unimproved land • Over 5 million hectares in the Sahel(semi-arid) including Burkina Faso, have been restored and additional 500,000t of grain each year and enough fodder to support a good number of livestock produced
	Fertilizer microdosing involves the placement of small amounts of fertilizers in hills of millet or sorghum.	• Crop yield increases of up to 100% and increase in farmers' incomes
	Climate Smart Village This is a community-based approach to boost farmers ability to adapt to climate change, manage risks, build resilience, improve livelihoods and incomes and reduce GHG emission.	• The approach is spreading to other villages in West Africa, including Jirapa in Ghana, Segou in Mali and Kollo in Niger
	Association of *Guiera senegalensis* trees with crops	• Increase in millet yield of about 245% and groundnut yield of 20%; increase in carbon stocks in soil and biomass; increase in incomes, reduction in vulnerability to droughts and reduction in wind erosion.
	Parkland	• Increase of millet and groundnut yields by 150% and 44% respectively; increase in carbon stocks of 60%; • increase in incomes; reduction in droughts due to increased local relative humidity, reduced potential evapotranspiration, and reduced temperatures
Senegal	Farmer Assisted Natural Regeneration (*Faidherbia albida* or *Piliostigma reticulatum*) stumps to regenerate and leave the cut leaves on the soil surface.	• Yield increase of millet greater than 150%; improvement of carbon stocks in soil and biomass; • increase in incomes; reduction in vulnerability to droughts; reduction in wind erosion; increase in wood production.
	Permanent Ridges/Vegetative Strips on Contours	• Increase in grain and straw production of 20% and 30% respectively; increase in soil carbon in the order of 14% after 2 years; • increase in soil water storage of 50-103%; return on investment of 20-60 % after 2 years of installation

	CSA Practice	Result
Senegal	Stone Bunds/ Half Moons/Vegetative Strips	• Flow of rain water slowed down thereby improving infiltration, regeneration of vegetation; • reduction of time required to draw water from wells from 2-3 hours to 1.3 hours
	Seasonal weather forecasts	• The approach was piloted in the Kaffrine region since 2011 but forecasts are now being made through a radio network in Kaffrine, Thies, Diourbel, and Louga regions. It is estimated that millions of users are now benefiting from the service
	Climate Smart Villages	• The spread is as outlined for Burkina Faso.
Sierra Leone	Lowland cropping	• 72% rice yield increase over upland rice in the rain forest zone, and 78 % yield increase over upland rice and 270% increase in returns to family labour in the savannah woodland
	The agroforestry practices are boundary planting, dispersed interplanting, fruit orchards and woodlots in the Makari village in the Makari Gbanti chiefdom in the Bombali district	• Over 25 years, potential returns at the village level for all systems were positive; $ 15,470, $135,812, $5,427,800, and $11,903,090 for dispersed interplanting, boundary planting, woodlot and fruit orchard respectively. • At the village level, estimated carbon storage was 1680 t CO2/hectare, 5,100 t CO2/hectare, 18,300t CO2/hectare and 42,000t CO2/hectare for boundary planting, fruit orchard, dispersed interplanting, and woodlot respectively.
	Conservation agriculture	• Yields of maize, rice and groundnut increased by over 100% compared to the baseline year (conventional practices), but were still low in 2012 (268kg/hectare, 1009kg/hectare,590kg/hectare for maize, rice and groundnut respectively. • Soil organic carbon in plots under conservation agriculture ranged from 1.22% to 4.53 % and averaged 2.5% in 2010, the first year of implementing conservation agriculture. In 2011, organic carbon varied from 2.01% to 5.89% and averaged 3.09% indicating a substantial increase in soil carbon. • Soil temperature and hardness measured on plots under conservation agriculture were less than the baseline values

	CSA Practice	Result
	Alley cropping (with *C. spectabilis* hedgerow shrubs Cassia)	• Significantly increased the maize yields from 666 kg/ha to 912 kg/ha; beans yields from 444 to 700 kgs/ha and sorghum from 1570 to 2180 kg/ha than grown in control.
	Conservation agriculture involving terracing on the hillsides improving the soil on the land under cultivation provided farmers with lime to enrich the soil which was degraded, and access to finance for inputs including fertilizers and seeds, and extension services. managing water run off to reduce erosion developing irrigation system	• 90 kg of seeds for Irish potatoes, and I harvested 1,250 kg of potatoes. 7 times better. • Farmers reported an increase in yields and income: more than 65 percent of the first potato harvest was sold in the market (after satisfying people's own food needs) whereas only 10 percentused to be sold in the past (WB 2010).
	F. albida with crops increased yield in Rwanda	• Maize intercropped with *Faidherbia albida*, yields can be slightly over 2 times under canopy compared with outside the canopy. Impacts depend on crops, species, densities, and different conditions among other factors and the project aims to maximize the benefits (Muthuri trees for FS 2012
Rwanda	Fertiliser microdosing increase profitability	• Among the highlights of the fertilizer profitability findings were: o Superb potential for fertilization of Irish potato (v/c ratios frequently >8) in about one-fourthof all communes. o Excellent potential (v/c ratios frequently > 3) for DAP fertilizer used on climbing beans in six zones; these zones are found in approximately one-third of Rwanda s communes; o Excellent potential for sweet potatoes (v/c for DAP/urea combinations generally >3) in about one-fifth of communes; o Good potential on sorghum (v/c ratios from 2-4) in 4 zones representing about one-fourth of communes. o Good potential (v/c ratios generally 2-3) for maize in five zones represented in at least one-third of the communes; o Fertilizer use was found to be profitable on irrigated rice, horticultural crops such as cabbage and on inoculated soybeans in a limited number of zones

	CSA Practice	Result
Zambia	Conservation farming, ripping is done during dry season (soon after harvest) using oxen or tractor	• Increased maize yield to 7.0 t/ha compared to 2.8 t/ha under conventional tillage in Zambia;
	Agro-Forestry in Zambia is using Musangu tree (*Faidherbia albida*),	• contributes to mitigation of climate change by above ground C sequestering of about 2.5 to 3.6 tons of carbon per hectare per year
Tanzania	In Karatu and Arumeru district of Tanzania, conservation farming, ripping is done during dry season (soon after harvest) using oxen or tractor	• Higher maize yield (1.9 to 2.0 t/ha) than direct seeding with jab planter (No till) which gave 1.7 t/ha in Tanzania
	Terraces in Arusha and Dodoma in Tanzania	• greater average yields of maize in maize (1.3t/ha) than minimum tillage alone (0.8 t/ha)
	In Arusha and Njombe Tanzania, biogas plant construction and use implemented by Tanzania Domestic Biogas Program (TDBP)	• Zero grazing livestock keeping is practiced reduced GHGs emission
	Terraces in Arusha and Dodoma in Tanzania	• greater average yields of maize in maize (1.3t/ha) than minimum tillage alone (0.8 t/ha)
	Participatory soil fertility management was done by African Highland Initiative (AHI) project in Kwalei village, Lushoto, Tanzania	• Increased N use efficiency through maximizing N uptake by crop and this is essential to achieve CSA
	Participatory soil fertility management was done by African NAFAKA project for rice production in Kilombero and Wami valleys, Tanzania	• increased N use efficiency through maximizing N uptake by crop and this is essential to achieve CSA
	The MICCA project implemented CSA through conservation agriculture, agro forestry and crop rotation, in Western side of Mountain Uluguru	• to reductions in GHG emissions
	More Resilient Food Crops (Sorghum and Cassava) and Risk Insurance in Tanzania	• Yield potential range of 1.5 to 4.6 t/ha compared to 0.98 t/ha for local varieties of sorghum. Resistant to Striga for Sorghum. Improved cassava varieties are more resilient under harsh conditions such as poor climatic conditions especially in low rainfall and low fertility areas.

	CSA Practice	Result
	Purchase of pasture land, conservation and storage of forage, integrating livestock and crop farming to recycle nutrient, consulting veterinarians, building community dips, and keeping more animals of resilient species by livestock keepers in Tanzania.	• Improved nutrition of household and diversify income generating activities
	Diversification and Value Addition to Crop and Tree Products *(Sclerocaryabirrea)* is an indigenous fruit tree (IFT) in Tanzania	• Fruiting within two years instead of the normal 10 to 15 years. Fruits from Sclerocarya trees are used to develop valuable products which can be traded in the local markets, urban centres and even internationally. Such products include a variety of cosmetic oils (selling up to USD 80
Tanzania	CHOLOLO ECOVILLAGE – smart village Ox-drawn tillage implements like the Magoye Ripper Soil water conservation measures, like contour ridges, fanya juu bunds, grass strips, and gully healing Farmyard manure Improved early-maturing, high-yielding seed varieties of maize, sorghum, millet, cowpeas and groundnuts Optimal plant population Community seed production Intercropping and crop rotation	• Okoa improved pearl millet harvest rande between 200 – 570 kgs / acre as compared to local pearl millet (30 – 300kgs/acre) • Early maturing sorghum produced 520 kgs / acre as compared to tradition sorghum (220 kgs) • Improved sunflower produced 210 – 390 kgs/ acre compared to tradition sunflower 30kgs/ acre - 290 kgs/ acre • Improved sunflower produced 60 littres/acre up to 110 litres/acre as compared to traditional (3 litres/acre – 40litres/acre) • Average increase of yield sorghum 137 %; pearl millet 105 %; sunflower 252 % and sunflower oil 383 % • Average income from sunflower oil increased from (12,800 to 82,000 tsh/acre) for a tradition variety and (120,000 to to 220,000 tshs/acre)
	Breeding mpwapwa breed with local breed to improve genetic potential local livestock breeds (supplied Mpwapwa bulls), improve productivity, lvestock health and feeding improved	• Improve genetic potential in Chololo Eco village • Doubled milk production a day. Also improved resistance to tick borne diseases and worms, • Reduced time to first mating • livestock management and disease

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.

Forum for Agricultural Research in Africa

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