State of Knowledge on CSA in Africa:

Case Studies from Burkina Faso, Senegal and Sierra Leone

FARA
Forum for Agricultural Research in Africa

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State of Knowledge on CSA in Africa: Case Studies from

Burkina Faso, Senegal and Sierra Leone

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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 Burkina Faso, Senegal and Sierra Leone

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

Yemi Akinbamijo
Executive Director, FARA

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Acronyms and Abbreviations

ANACIM	Meteorological Agency, Senegal
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Plan
CARE	International Cooperative for Assistance and Relief Everywhere
CCAFS	Climate Change, Agriculture and Food Security Programme of the CGIAR
CGIAR	Consultative Group on International Agricultural Research
CILLS	Comité permanent Inter-Etats de lute contre la sécheress dans Sahel
CIMMYT	International Maize and Wheat Improvement Center
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
DSSAT	Decision Support Software for Agrotechnology Transfer
ECHAM 5	Fifth Generation Climate Model Developed at the Max Planck Institute for Meteorology
ECOWAP	Economic Community of West African States Agricultural Policy
ECOWAS	Economic Community of West African States
ENDA	Energie Environnement Developpement
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
GCM	General Circulation Model
GEF	Global Environmental Facility
GHG	Green House Gas
GOSL	Government of Sierra Leone
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
INERA	Institute de l'Environnement et de Recherches Agricoles
ISRA	Institut Senegalais de Recherches Agricoles

LGP	Length of Growing Period
MARK 3	Climate Model Developed at the Australia Commonwealth Scientific and Industrial Research Organization
MIROC	Model for Interdisciplinary Research on Climate Developed at the University of Tokyo Center for Climate System Research
NAFSIP	National Agriculture and Food Security Investment Plan
NAPA	National Adaptation Programme of Action
NARES	National Agricultural Research and Extension Systems
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 Leone Import and Export Promotion Agency
SLM	Sustainable Land Management
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme

Executive Summary

African agriculture is highly vulnerable to climate change and urgent actions are required to combat its impacts. The Forum for Agricultural Research in Africa (FARA), in collaboration with the Norwegian Agency for Development Cooperation (NORAD) recognizing the need to promote Climate Smart Agriculture (CSA) launched a survey of CSA in Africa. The CSA approach promotes increased agricultural productivity, adaptation to climate change and mitigation of greenhouse gas emissions. This report on Least Developed Countries (LDCs) in West Africa - Burkina Faso and Senegal mainly in the semiarid and sub-humid agro-ecological zones and Sierra Leone in the sub-humid-humid zone forms part of the larger study.

The primary purpose of the study 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:

(1) identify, document and collect data and information on successful climate-smart agricultural practices for scaling up and out;

(2) document and collect data and information on policies 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 opportunities that may facilitate or hinder scaling up and out of CSA practices in West Africa; and

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

Following an inception meeting at the FARA secretariat, Accra, in which the survey instruments were developed, a desk study 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 Burkina Faso, Senegal and Sierra Leone. The next step was a rapid field survey involving nationals (key informants) based in the three countries that obtained and collated information/data from researchers, extension workers, farmers and policy makers.

Annual average temperatures in Burkina Faso, Senegal and Sierra Leone have increased over the past 40 years by about 0.6^{o}C - 0.9^{o}C and predicted to increase by 1^{o}C-3^{o}C by 2050 over a 2000 baseline. Average annual rainfall has fluctuated over the past 40 years, but overall, has declined. It is predicted to increase or decrease, between 2000 and 2050 depending on GCM model used. Projections indicate that changes in climate can result in drop in yields of the major staples by 5-25% or more by 2050 compared to a 2000 baseline in these countries if appropriate measures are not taken by policy makers and farmers.

The impacts of changes in Length of Growing Period (LGP) in the semi-arid livestock systems are projected to be stronger in Burkina Faso and Senegal compared to Sierra Leone.

While agricultural growth in Burkina Faso declined from 6.6% per annum in 2003-2008 to 5.2% per annum in 2010, that in Senegal and Sierra Leone increased from 2.3% and -9.9% respectively in 2003-2008 to 6.2% and 5% respectively in 2010, indicating that the CAADP target of 6% per annum agricultural growth is not being fully met. The external trade balance for all three countries has been negative for several years, implying opportunities for regional trade if productivity can be improved through CSA.

Farmers in all the countries and agro-ecological zones are middle-aged to old, poor, food insecure and mainly illiterate (30-39% female literacy; 53-62% male literacy) operators of rain fed farming systems, cultivating small farms (<1-2 hectares) with soils of low fertility, and producing unstable and low crop yields (cereal yields on uplands of 0.5-1t/hectare). Farm sizes in semi-arid - sub-humid zones of Burkina Faso and Senegal tend to be larger than in the humid zone of Sierra Leone. Women form over 50% of the agricultural workforce but over 90% of households are headed by men. Access to agricultural credit by male and female farmers and ownership of land by women are poor. The adaptive capacity of farmers, with regards to climate change, in the surveyed countries is low as a consequence of the poor socio-economic circumstances and harsh biophysical environments that they have to contend with.

Best Bets and success stories of climate smart agriculture practices, as indicated by increases in crop yields, incomes or adoption by farmers are available for the major agro-ecological zones in Burkina Faso, Senegal and Sierra Leone. They consist of technological options based on the principles of Sustainable Land and Water Management (SLWM); Integrated Soil Fertility Management (ISFM), risk management approaches such as seasonal weather forecasts, index-based crop insurance and safety nets; and participatory climate smart village approaches. The Zai pit, a successful SLWM practice reported is indigenous to Burkina Faso. Implementation of technological practices has been mainly at the plot and farm levels and not at the landscape level.

AU-CAADP developed a framework on climate change adaptation and mitigation which deals with CSA. ECOWAS developed a Regional Policy on Agriculture, an Environment Policy and a Regional Action Programme to Reduce Vulnerability to Climate Change in West Africa but they do not focus on CSA. National policies specifically on climate smart agriculture are lacking in the surveyed countries but the NAFSIPs, that is, the National Programme for Food Security (PSNR) of Burkina Faso, the National Agricultural Investment Plan (PNIA) of Senegal and the Smallholder Commercialization Programme (SCP) of Sierra Leone include food security, adaptation and some mitigation elements which can be used as entry points for mainstreaming CSA.

Several gaps concerning the development and implementation of CSA are identified in the areas of production and commercialization; 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 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 on all needed elements. Improved high yielding varieties of millet, sorghum, maize, groundnut, cassava and rice tolerant to stresses such as drought, floods, salinity and diseases are suitable 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) pigs and poultry are suitable for CSA.

The key recommendations are as follows:

(i) Measures should be put in place to improve the stability of the yields of the major food and cash crops so as to improve food security in West Africa through CSA;
(ii) Best Bet practices based on SLWM, ISFM and risk management should be scaled up and out;
(iii) Interventions aimed at reducing or eliminating the gaps identified by the study in priority areas 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;
(iv) Short duration, drought tolerant, high yielding, disease resistant varieties of millet, sorghum, maize, groundnut, rice, cassava and other staples should be promoted as integral components of SLWM and ISFM; Livestock breeds that combine productivity with hardiness should be promoted;
(v) Policies on CSA should be mainstreamed into agricultural development policies. In addition, national policies on the agriculture, forestry, health, water, social, education, energy and infrastructure sectors should be aligned for successful CSA;
(vi) 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;
(vii) The similarities in agro-ecological zones between countries should be exploited through information sharing and replication of lessons learned from research and development and policy across West Africa;
(viii) Existing frameworks for the NAFSIPs which are well set up and in line with government's policies on decentralization to districts and lower levels should implemented;
(ix) 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, in a situation where governments cannot fully fund national budgets;
(x) Integration of adaptation and mitigation activities through climate smart agriculture should be used by the Least Developed Countries and partners to improve access to

adaptation and mitigation funds.

The survey generated information on the state of regional and national policies on and practice of climate smart agriculture in Burkina Faso, Senegal and Sierra Leone. It should inform NORAD, FARA, NARES and other stakeholders with regards to the design of follow-up interventions on mainstreaming of CSA into the NAFSIP's, capacity building, research and development projects on scaling up and out of CSA, policy formulation and financing

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 temperatures and changes in precipitation is clear. In recent years, impacts of climate change are already affecting agriculture, ecosystems, biodiversity and people.

West 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 West 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. West 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 are managed are needed to address the challenges of meeting food security in the face of climate change, population growth and migration as well as other stresses while preserving the natural resource base for agriculture.

The need to respond to climate change has been recognized for several years at the continental and regional levels (ECOWAS, 2009a, 2009b). One of the strategies adopted under Pillar I of the Comprehensive Africa Agriculture Development Programme (CAADP) is the adoption of sustainable land and water use practices in order to contribute to CAADP's 6% annual growth of agriculture. 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 MTOP, covering the period 2014 – 2018. The strategic plan and MTOP are based on "Enhancing African Agricultural Innovation Capacity" as a pathway to broad-based improvements in agricultural productivity, competitiveness and market access. It addresses three strategic priorities namely:

- Visioning Africa's agricultural transformation through foresight, strategic analysis and partnerships to enable African agricultural stakeholders to 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 West 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 can be used to support evidence-based CSA policy and programme design, and performance monitoring. The 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 was 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.

2. Methods

2.1 Inception Meeting

The initial step was a meeting at FARA headquarters, Accra, at which a common understanding of the terms of reference (Annex 1) was obtained. Burkina Faso and Senegal were selected to represent the semi-arid - sub-humid zones and Sierra Leone the sub-humid-humid zone of West Africa.

2.2 Sources of Data and Data Collection

The second step was a 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. The third stage was a rapid field survey in which information/data was obtained by nationals (key informants) in the three countries (Annex 2) from national and international research and development organizations, farmers and policy makers.

Limitations of the survey are that rigorous systematic farm-level data were not obtained to enable valid statistical analysis and projections and the same set of data were not always available for all the three countries and all CSA practices reported.

2.3 Study Area

Burkina Faso is situated between 9° and 15° north latitude and between 2° 30' east longitudes and 5° 30' west longitudes. It is landlocked being bounded in the north and north west by Niger, in the southeast by Benin and in the south by Cote d'Ivoire, Ghana and Togo. It has an area of 274,000 km^2. Locally, there are 3 climatic zones within Burkina Faso: Sahelian with annual rainfall up to 600 mm, sometimes for less than 2 months (semi-arid zone); Sudano-Sahelian zone with rainfall of 600-900 mm (semi-arid-sub-humid) occupying the largest part of the country with rainy season of 4-5 months; Sudanian zone with rainfall of 900-1200 mm (sub-humid). The dominant soils are low activity clay soils, generally sandy of very low organic matter content and fertility. The farming system in these zones is agro-pastoral.

Senegal is between 12.5° and 16.5° north latitude and is bounded on the north by Mauritania, in the east by Mali and south by Guinea Bissau and Guinea and on the west by the Atlantic Ocean. It has an area of 196,712 km^2. Annual rainfall ranges from 300 mm in the semi-desert north to 1200 mm in the south. Three main climatic zones are locally demarcated: sub Guinean (sub-humid) in the south, Sudanian (semi-arid-sub-humid) in the centre and Sahelian (semi-arid) in the north. In general, the soils are low activity clay soils, sandy and of low organic matter content and fertility. The farming system is agro-pastoral.

Sierra Leone is located between 6° 55' and 10° 00' and between longitudes 10° 16' and 13° 18' along the west coast of Africa. It is bounded on the north and northeast by Guinea, in the south and south-east by Liberia and in the west by the Atlantic Ocean. It has an area of 72,300 km^2. Four main agro-climatic regions namely coastal plains (3000 mm rainfall), savannah woodland (2280 mm), transitional rainforest savannah woodland (2730 mm), rainforest (2660 mm) are delineated locally. However, all receive above 2000 mm rainfall and are grouped as being in the sub-humid-humid zone for the purpose of this study. The low predominant soils are activity clays soils which highly leached, acidic, of relatively low fertility. However the soils generally have higher organic matter contents than the soils of the semi-arid zones and fairly good physical properties. Sierra Leone lies within the agro-sylvo-pastoral belt of West Africa.

3. Climate change and its implications for agriculture and livestock production

3.1 Burkina Faso

Past and Recent Climate

For the period 1961-1990, average rainfall was 900-1200mm, 600-900mm, 300-600mm in the south Sudanian, north Sudanian and Sahelian regions respectively. Between 1920 and 2000 annual rainfall at Quagadougou fluctuated but the overall trend was a decline from 860 to 650 mm (Burkina Faso, 2007). Rainfall in Burkina Faso has been steady between 1992 and 2012 but was15% below the 1920-1969 average (FEWS NET, 2012a).

Between 1920 and 2000 average annual minimum and maximum temperatures fluctuated but the overall trend was a rise in minimum temperature of 21 to 22.5°C and 34.7 to 35.2°C in maximum temperature. Average temperature increased by 0.6°C since 1975 (Burkina Faso, 2007; FEWS NET, 2012a).

Climate Scenarios 2000-2050

Assuming an optimistic scenario (A1B)[1], CNRM-CM3 and MIROC 3.2 GCM models predict increase in rainfall in large areas of the country, with MIROC 3.2 predicting the highest rainfall. On the other hand CSIRO Mark 3 predict decrease in rainfall of 200 to 100 mm in the central and southwestern parts of Burkina Faso. ECHAM 5 predict small changes, that is, decrease of 50 mm or increase of 50 mm in the entire country (Some, et al., (2013).

Projected 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).

3.2 Senegal

Past and Recent Climate

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

Climate Scenarios 2000-2050

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

[1] A1B is a GHG emission scenario 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.

projects a reduction of 50 mm to 200 mm in annual rainfall in eastern Senegal. All models project temperature increase of 1-1.5^oC. CSIRO Mark 3 and MIROC 3.2 indicate the lowest increase in temperature.

3.3 Sierra Leone

Past and Recent Climate

Average annual rainfall in the duration between 1961-1990 was 2346mm (GOSL, 2007). It varied between 3659mm in Bonthe (south) to 2618mm in Kabala (north). Average annual rainfall has fluctuated over time but overall rainfall has decreased since 1960. Between1990-1999 it averaged 2891mm in Bonthe.

Annual average temperature between 1961-1990 in Sierra Leone was 27^oC (GOSL, 2007). It has increased by 0.8^oC since 1960 with average of 0.18^oC per decade (Tarawalli, 2012). This compares unfavourably with the rate of global warming between 1998 and 2012 of 0.05^oC to 0.15^oC (IPCC, 2013).

Climate Scenarios 2000-2050

Johnson, et al., (2013), reported varied outcomes for rainfall for an optimistic scenario. The CNRM-CM3, CSIRO Mark3 and ECHAM5 global circulation models indicate rainfall varying from -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.

The models used gave consisted predictions for temperature, with increases always predicted, CSIRO Mark3 and MIROC 3.2 indicate increases of 1-1.5^oC average daily maximum temperature. CNRM-CM3 indicates increase of 2-2.5^oC 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^oC and that increases would be greater in the north and northeast than in the rest of the country.

3.4 Hazards, Impacts of Climate Change and Implications for Agriculture

The climate change hazards most frequently perceived by farmers as reported in the survey by key informants are shown in Table 3.1. Droughts, floods and high temperatures are reported for all countries.

Burkina Faso

Loss in crop yields, degradation of the ecosystem and loss of biodiversity are common impacts reported for all zones. In the Sahelian zone there is very strong erosion and land degradation, reduction in cultivable land, lack of forage, reduction in numbers of livestock, incomes and labour force. Migration of men and youth takes place, leaving women and children behind.

Table 3.1 Climate Change Hazards in Burkina Faso, Senegal and Sierra Leone

Burkina Faso	Senegal	Sierra Leone
Droughts , flooding, sand storms, temperature increases in the Sahelian zone; drought, flooding, temperature increase in the Sudano-Sahelian and Sudanian zones	Reduction in rainfall, recurrence of droughts, high temperatures, salinity of agricultural lands, increase of floods in the Sudano-Sahelian zone;	Bushfires, dry spells high temperatures in the savannah; dry spells, droughts in transition zone; late rains, early rains, droughts, landslides and floods in the forest and coastal zones.

In the Sudano-Sahelian, there is increased pressure on the land, and frequent conflicts between crop and livestock farmers.

Senegal

Loss of agricultural land, reduction in crop yields (30-60%), increase in rural poverty, and food insecurity are reported for all zones as the impacts. In the Sudano-Sahelian zone the impacts indicates increase in migration of youth and men from rural areas, reduction in biodiversity of woody plants, shift of some plant species to the rainier south and reduction in forage production. In the sub-humid zone the impacts result in increase of migration of youth and women from rural areas.

Sierra Leone

The impacts reported include reduction in crop yield, acreage cleared, acreage planted, acreage harvested, quality of crop produce harvested, number of livestock, pasture/forage for livestock, incomes, food security and poor health of farmers. In the woodland savannah (northern region) the top three in descending order of importance are reduction in acreage harvested, acreage cleared and crop yield. In the forest/savannah woodland transition (southern region) the ranking is reduction in acreage cleared, crop yield and acreage planted. The order is reduction in acreage cleared, crop yield and acreage harvested in the forest (eastern region) and reduction in acreage planted, acreage harvested and quality of harvested produce in the coastal (western region)

3.5 Impacts on Crop Systems and Implications for Agriculture

It should be emphasized that a major impact of the past, present and future rainfall and temperature on the agriculture sector of Burkina Faso, Senegal and Sierra Leone is and will be on crop yields (a key component of production). This is important because increased agricultural production is one of the cornerstones of CSA. CSA must therefore deliver increased and stable yields and improved livelihoods through the uptake of improved technologies, availability of safety nets and weather-based insurance schemes. Estimates of the changes (positive and negative) in crop yields as a consequence of climate change for Burkina Faso, Senegal and Sierra Leone between 2000 and 2050 (Jalloh, et al., 2013) are outlined:

Burkina Faso

The results of the GCMs used in conjunction with DSSAT give the following results: all 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 the country, especially in the Central and South Western regions. All models project a decline in cropping area in the northernmost region, the loss being greatest for ECHAM 5. However, small increases are projected for scattered areas in the central region. Maize yield increases of 5-25% are projected for a significant area of the country. All models show a decline in maize yield in the current maize growing areas.

Senegal

There is agreement in projections by most models; they show yield loss of 5-25% for groundnut and CNRM-CM3 and ECHAM 5 project yield loss greater than 25%. However there are small areas for which CSIRO and MIROC project yield increase. All models indicate increases in maize yields of 5-25%, in most areas but some yield decreases in small areas. CNRM-CM3 and ECHAM 5 show greater loss in maize yields compared to the other two models. Projected yield loss is greater by ECHAM 5 than other models. Scenarios for rice are similar to those for maize.

Sierra Leone

The GCM's were used in conjunction with DSSAT crop model to project yields. Against the 2000 base line year, CNRM-CM3 and CSIRO-Mark3 show yield increases of rain fed rice of 5-25% throughout the country. 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.

3.6 Impacts of climate change on Livestock Systems

Climate change has contributed to change over time in transhumance patterns in Senegal and neighbouring countries thereby narrowing the movement of pastoralists (Msangi, 2014). There are few models dealing with livestock and none deal with heat or water stress which are crucial in the West African situation (Msangi, 2014). One of the few studies in this area is that of Thornton, et al., (2006) who projected drop in length of growing period (LGP) that will negatively impact both livestock and crop systems with serious implications for food security.

The impacts in the semi-arid livestock systems are projected to be stronger for Burkina Faso and Senegal in the semi-arid- sub-humid zone compared to Sierra Leone in the sub-humid-humid zone (Table 3.2). Other impacts on livestock systems are likely to be reduced water availability, changes in severity and distribution of livestock diseases, changes in the quality and productivity of forage.

3.7 Implications for Markets, Finance and Policy

Changes in length of growing period resulting from rainfall and temperature changes have implications for 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 lower yields and comparative advantage. Improved access to markets both locally and internationally would provide a driving force for increasing agricultural productivity. To counter the predicted drop in agricultural production, financial support in the form of investments and smart subsidies for the small scale farmers to enable them adopt CSA should be considered by governments.

Baseline Factors and Variables Related to the Adoption of Climate Smart Agriculture[1]

Econometric models have been used to analyse the adoption of improved agricultural technologies by small scale farmers in West Africa (Adesina, et al, 1999). The necessary data were obtained from farm-level surveys utilizing pretested questionnaires administered by enumerators as well as focus group discussions with farmers. Bearing in mind the scoping nature of the present study, broad factors and variables that are usually related to the adoption of improved agricultural technology have been considered. It is assumed that they are applicable to climate smart agriculture practices. They include agricultural GDP growth, patterns of crop production, poverty levels, incomes, trade, food security, farmers and farm characteristics and institutional factors.

National Development Indicators

The vulnerability to climate change and other shocks, state of national economies, human capital, and importance of the agricultural sector in the economy influence the ways and extent of responses (adaptation, mitigation, improved productivity) to climate change. The indicators considered are shown in Table 3.3 and the figures making up Annex 3.

Data from UNCTAD (2013) shows that for Burkina Faso, GDP growth varied between years but increased slightly to above 6% between 2002-2008 and 2013. For Senegal the variability was less with GDP growth always below 5%. Growth of GDP in Sierra Leone was also slow until a dramatic increase of 17 and 19% occurred in 2012 and 2013 respectively (Annex Figure 1), which was due to revenues from recent iron ore mining. GDP of West African countries could decline by 2%-4% by 2100 as a result of losses in the agricultural sector due to climate change and variability (Namara, et al., 2011).

Agriculture accounts for a substantial 19% to 49% of GDP (Annex 3 Figures 1 and 2) in the three countries. CAADP (2003) targets an agricultural growth of 6% per annum in Africa; agricultural growth in West Africa has fluctuated but lower rates were generally achieved. Between 1995 and 2003, Burkina Faso, Senegal and Sierra Leone had average annual agricultural growth rates of 6.6%, 2.3 % and -9.9% respectively when Sierra Leone was embroiled in civil war. In the 2003 to 2010 period Burkina Faso, Senegal and Sierra Leone recorded rates of 5.2%, 6.2% and 5% respectively.

In addition to agricultural GDP growth, Total Factor Productivity (TFP) has been used to measure agricultural productivity in West Africa. IFPRI (2006) reported TFP was 2.1% per annum between 1985 and 2002 in the Coastal countries of West Africa and only -0.29% per annum in the Sahelian countries during the same period. Information on TFP for cropping systems in West Africa specifically under climate smart agriculture is not available.

The development indicators show some variability between the three countries but the overall picture is that of high economic vulnerability to a number of shocks, low levels of economic activity, and high levels of poverty and food insecurity. This justifies major changes in the way land, water, soil nutrients and genetic resources are managed to meet the challenges of attaining food security in the face of climate change and hence a need for adopting climate smart agriculture.

[1] Graphs showing recent trends in indicators are presented in the Annex 3.

Table 3.2 Length of growing period (2050 est.) for Burkina Faso, Senegal and Sierra Leone

Country	LGA	LGH	MIA	MRA	MRH	OTHER	TREEC
Burkina Faso	2	2		2		2	
Senegal	2		1	2		1	
Sierra Leone		1			1	1	1

Source: Thornton et al. (2007)

Notes: An A1 scenario was assumed which represents a future of very rapid economic growth, global population peaks in mid-century, and declines thereafter and the rapid introduction of new and efficient technologies.Rating 1 indicates moderate losses (5-20%) in at least 50% of the system; Rating 2 indicates substantial losses (>20%) in at least 50% of the system.

Land Use System Codes:
LGA = Livestock only systems arid and semi-arid; LGH = Livestock only systems humid and sub-humid; MIA = Irrigated mixed crop/livestock systems, arid-semi arid; MRA = Rain fed mixed crop/livestock systems, arid-semi arid; MRH = Rain fed mixed crop/livestock systems, humid-sub-humid; OTHER = other systems, including root-based and root- based mixed; TREEC = Tree crop systems

Table 3.3 Factors and variables related to CSA in Burkina Faso, Senegal and Sierra Leone

Variables	Burkina Faso	Senegal	Sierra Leone
Population (x 10^6) 2010	16.5	12.4	5.9
Pop. Growth %	3.0	2.7	2.2
Land area km^2	274,000	196,712	72,300
GNI per capita (US$)	670.0	1,040.0	580.0
Economic vulnerability Index[a]	37.5	36.1	48.5
Human Assets Index[b]	29.2	47.0	24.8
Human Development Index Rank	183.0	154.0	177.0
Multi-dimensional Poverty Index[c]	0.5	0.4	0.4
Food security Index (max/100	31.6	38.4	35.8
Agriculture: forestry, hunting and fisheries contribution to GDP (%) 1999 - 2001	35.0	18.9	48.6
Agriculture: forestry, hunting and fisheries contribution to GDP (%) 2009 -2011	35.1	17.1	57.0

Source: UNCTAD (2013).

NOTES

[a] EVI is based on (i) natural shocks(index of instability of agricultural production); share of the population that has been a victim of natural disasters); (ii) trade related shocks (index of instability of exports of goods and services); (iii) physical exposure to shocks (share of the population living in low-lying areas); (iv) economic exposure to shocks (share of agriculture, forestry and fisheries

in GDP); index of merchandise export concentration); (v) smallness(population in logarithm); and (vi) remoteness (index of remoteness). Higher EVI values indicate higher vulnerability;

[b] HAI is based on indicators of (i) nutrition (percentage of population that is undernourished); (ii) health (child mortality rate); (iii) school enrolment (gross secondary school enrolment ratio); and (iv) adult literacy rate. The lower the HAI values the weaker the human asset development;

[c] Higher MPI values indicate greater poverty

Level of Production of Major Staples and Trade

Changes in acreage harvested, yields and production of millet and rice are shown in Appendix 3, Figures 3, 4 and 5. The figures were constructed from data in the FAO statistical database (FAO, 2015). Annual variability (instability) in acreage harvested, crop yields and production of major staples and implications for CSA are analysed in this section. Yields of millet are low (less than 1t/ha), and annual variability high between years.

Variability in crop yields between years may be due to changes in weather, crop variety, and crop and soil management. This finding underscores the difficulty of fixing a baseline year for crop yield and production, rather than examining recent trends.

For Burkina Faso, millet production correlates better with acreage (R2 = 0.52) compared to yield (R2 = 0.46). For Senegal, correlation between millet production and acreage (R2 = 0.77) is similar to that between production and yield (R2 = 0.79). Yields of rice in Burkina Faso and Senegal are higher than in Sierra Leone where lower yielding upland rice production systems are very significant (Annex 3; Figures 6, 7 and 8). Moreover, the variability in annual yields and production within countries makes governments' planning on local production and imports difficult.

Rice production in Burkina Faso correlates strongly with acreage (R2 = 0.94), and slightly with yield (R2 = 0.20); in Senegal rice production correlates with acreage (R2 =0.92), and yield (R2 =0.94); in Sierra Leone production correlates with acreage (R2 = 0.64), and with yield (R2 = 0.74).

The importance of analysing the components of crop production is that increase in crop production due mainly to expansion of land brought into cultivation (high correlation between acreage and production compared to that between yield and production) may entrain deforestation and reduction of carbon storage in vegetation and soil (Table 3.4). Sustainable intensification of cropping should lead to increases in crop yield with little or no expansion in acreage of land cropped and maintenance of soil quality. High population density and small land size force farmers to intensify production or find alternative livelihoods. Sustainable intensification of farming is climate smart.

Table 3.4 Projection of carbon stored by agroforestry systems in the savannah woodland zone of Sierra Leone over 25 years

Area	Boundary plantings(100 m)	Dispersed interplanting (t CO2/ha)	Fruit orchard	Woodlot
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: FARA survey (2014); Bjorkemar (2014)

Climate change, through changes in land suitability for crops and comparative advantage in the production of certain crops will affect the direction of trade flows for commodities in the international markets such as rice. Rapid urbanization in West Africa and changes in diets and food consumption habits have made rice (easy to store and cook) a very important commodity in all three countries. Annex 3 Figure 9 shows variation in tonnage of imports between years, but overall there are increases in imports of rice from outside Africa. The spike for Sierra Leone corresponds to the lifting of the United Nations trade embargo on Sierra Leone at the end of the civil war. Climate smart agriculture leading to increased local productivity of rice will reverse this trend. When imports are reported in terms of value (Annex 3, Figure 10) there is still annual variability and the values in 2011 are higher than those in 2001 for all countries.

It is worth highlighting , in the context of political economy that trade is liberalized in all three countries and external trade balance for Burkina Faso was -19.6% of GDP during 1980-1989; -13.5% GDP during 1990-1999; and -14.2% of GDP in 2000-2010, for Senegal the corresponding balances were -12.1%, -7.2 % and -15.7% and for Sierra Leone -3.1%, -4.5% and -13.9% (World Bank, 2013). These negative trade balances suggest opportunities for improving regional trade and food security through CSA. Cross border trade and smuggling of staples across national borders is also important for food security. This trade is influenced by the state of national economies (for example exchange rates between the Guinean Franc and Leone to the US dollar) and political stability in countries. A constraint to trade is that the implementation of ECOWAS protocols on movement of goods and persons is sometimes not respected at borders between Sierra Leone and its neighbours (Bauer, et al., 2010; NRC, 2010).

Farmer and Farm Characteristics

Knowledge of farmer and farm characteristics facilitates the appropriate targeting of agricultural technologies to households and locations where they are most suited and therefore stand good chances of adoption. It also helps to assess the willingness to take risks (Charness and Viceiza, 2011) and facilitates monitoring and evaluation of interventions.

Farmers are categorized here mainly by age, literacy, farm size and gender. The results of the survey show that farmers tend to be middle aged to old and are mainly illiterate. Farm sizes are larger in the semi-arid zones compared to the humid zone but are in general small, so output per farm is low. While women constitute the majority of the agricultural labour force, men are the heads of households and make the decisions regarding household and farm management, which may not be in the overall interest of the sector. Characterization is also done in terms of social and natural capital. Social capital is the capacity for collective action (Richards, et al., 2004). Farmers coming together in groups to alleviate labour shortage at periods of peak labour demands, and responding to major shocks such as floods and membership of community based organizations and societies are examples of social capital exhibited in all the surveyed countries. Natural capital is mainly the land and water resources which are of better quality (higher soil organic carbon content, better water resources) in the sub-humid and humid zones compared to the semiarid zone. Off farm employment (an adaptation option to climate change) is rated as low, suggesting need to adapt within agriculture. All of these constraints contribute to very low crop productivity and are challenges for successful CSA.

Institutional Factors

Access by farmers to credit and markets improves returns from adoption of CSA practices. In addition, implementing CSA requires a marketing system that conveys timely and accurate information on demand and supply. Access to formal credit is difficult for smallholders with little collateral, as agriculture is deemed a risky enterprise with slow turnover. The poor feeder roads between villages and towns inhibit access to markets. Access to credit and markets is rated poor to moderate for the three countries.

Secure access to agricultural land or ownership is a prerequisite for investment in soil conservation technologies and tree planting that pay off over time. Access to land in all countries is rated as satisfactory for males of land-owning families in rural areas but less so for women and non-indigenes. Governments' agricultural extension services are poor to moderate because of funding and capacity constraints; NGO's complement with contributions at community levels.

The enabling environment for CSA also requires good inter-ministerial cooperation in priority setting and good coordination between ministries, NGOs and civil society in project implementation. At the government level, 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. Institutions responsible for agricultural policy in all three countries suffer from weak capacity in policy analysis. The level of cooperation and coordination is rated poor to moderate and level of decentralization of the functions of Ministries of Agriculture to districts is rated as satisfactory.

4. Successful Climate-Smart Agricultural Practices

4.1 Adaptation and Mitigation practices in use

Table 4.1 shows the CSA practices reported by key informants in the FARA (2014) survey. The agronomic practices mainly fall under the broad umbrellas of sustainable land management and integrated soil fertility management (Lineger, et al., 2011).

Some practices, for example, use of adapted crop varieties, fertilizers and agroforestry are in use across diverse agro ecological zones. Zai pits (Plate 4.1 and stone bunds (Plate 4.2) were more common to the semi-arid and sub-humid zone. The latter are labour demanding technologies but the pressure on small scale farmers to slow down desertification in these zones is so great that tedious soil management practices (see also Plate 4.3) are being adopted, especially during periods when farmers are supported through donor funded agricultural development projects. Cloud seeding, a high-technology undertaking in which light aircraft is used to inject salt crystals (silver iodide or potassium chloride and sodium chloride) into pregnant clouds to force them to shed rain was only reported for the Sahelian zone of Burkina Faso.

Although composting and crop residue restitution was reported only for Burkina Faso, use of these practices is widespread in West Africa (Bationo, et al., 1996). Farmers in all countries are taking part in participatory development and dissemination of CSA practices through Farmers Field Schools; farmers in Senegal and Burkina Faso are involved in Climate Smart Villages for building sustainable adaptive capacity.

Plate 4.1 Zia pits in semi-arid West Africa

Qualitative estimates of the benefits of the CSA practices in use in terms of their potential contribution to production, adaptation and mitigation are reported CCAFS (2014). In general the practices in use are geared more towards improving production and adaptation than to mitigation of greenhouse gas emission into the atmosphere.

Source: Lineger et al. (2011)

Plate 4.2 Stonelines/bunds in semi-arid West Africa

However many can potentially provide

all three benefits, which is the essence of climate smart agriculture.

Plate 4.3 Women participating in soil and water conservation in the semi-arid zone of West Africa

Best Bet Climate Smart Agriculture Success Cases

Among the several CSA component technologies reported to be in use, there are some for which indicators of success are available and these are shown in Table 4.1. The biophysical and socioeconomic circumstances under which they were proven are shown in Table 4.2. Use of improved crop varieties is primarily for adaptation purposes but complement other CSA measures. Improved high yielding drought tolerant varieties of cereals, grain legumes, roots and tubers with tolerance to major disease and pests developed by national programmes in partnership with CGIAR centres are being used in all agro-ecological zones and countries. They give yield increase often more than 100% over local varieties. Well known examples are NERICA and drought tolerant maize. These improved varieties used in conjunction with the Sustainable Land Management practices have the potential to improve yields and productivity considerably.

Table 4.1: CSA Adaptation Practices reported from the Study

AEZ	CSA Practice	Short description	Indicators of Success
Burkina Faso			
Semi-arid-sub-humid	Stone bunds/ zai pits along contours	Stone bunds constructed along contours combined with Zai pits (Figure 4.1) that are filled with composts or manure. The tiny pits are 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)	Increase of sorghum and millet yields of up to 1t/hectare (100%) over unimproved land
	Farmer assisted natural regeneration	Farmers allow trees *(Faidherbia albida or Piliostigma reticulatum)* stumps to regenerate and leave the cut leaves on the soil surface.	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, thereby increasing food security for millions and enhancing their resilience to climate change. Contour bunds have been established on 200,000-300,000 hectares of lands in the Sahel.
	Fertilizer micro dosing	The technology 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 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 Yatenga village in Burkina Faso	The approach is spreading to other villages in West Africa, including Jirapa in Ghana, Segou in Mali and Kollo in Niger

AEZ	CSA Practice	Short description	Indicators of Success
Senegal			
Semi-arid	Association of *Guiera senegalensis* trees with crops	Agroforestry system involving trees in fields of major food and cash crops	Increase in millet yield of up to 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	This is an agroforestry system involving crops/livestock integration. Faidherbia albida sheds its leaves at the start of the rainy season, thus increasing soil organic matter content.	Increase of millet and groundnut yields of up to 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.
	Farmer Assisted Natural Regeneration	Same as outlined for Burkina Faso	Yield increase of millet of up to 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.
	Stone Bunds/ Half Moons/ Vegetative Strips	Soil and water conservation devices including stone bunds, half-moons and vegetative strips that reduce runoff and increase infiltration of rainfall.	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
Sub-humid	Permanent Ridges/ Vegetative Strips on Contours	This is a soil and water conservation system based on reducing run off and improving water infiltration and retention	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.

AEZ	CSA Practice	Short description	Indicators of Success
Semi-arid-sub-humid	Seasonal weather 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 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 project was launched in 2011 in Kaffrine village in Senegal	Increase in farmer productivity; increase in incomes.
Sierra Leone			
Sub-humid-humid	Lowland cropping	Lowland wet season 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.	About 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 labor in the savannah woodland. Lowland rice cropping has been practiced for several years, on thousands of hectares of land by thousands of farmers in all the districts.
	Agroforestry	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 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.

AEZ	CSA Practice	Short description	Indicators of Success
Sub-humid-humid	Conservation agriculture	CARE implemented a conservation agriculture project in the savannah woodland from 2010 to 2012 involving mulching, minimum tillage, cover cropping and crop rotation	Yields of maize, rice and groundnut increased by about 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. Soil temperature and hardness measured on plots under conservation agriculture were less than the baseline values.

Source: FARA survey (2014); Danyi, (2012); Katta, (2012) Neate (2013); Tabo, et al., (2006); CCAFS (2013).

The FARA survey (2014) revealed the use by farmers of a range of sustainable land management practices (Table 4.3) which can be regarded as success stories in West Africa: stone bunds/vegetative strips on the contour is widely used in the semi-arid belt which extends through Burkina Faso and several West African countries including Niger, Mali, and Senegal. Harvesting of rainfall is crucial in this zone where rainfall is very low, erosion high and the soil degraded. The major constraint to adoption of stone bunds on contours is the initial cost which can be about $200/hectare and 150 person days of labour/hectare (Neate, 2013).

Efficient fertilizer use, as part of integrated soil fertility management, is being promoted and adopted in the West Africa region to reduce nutrient losses to the environment, improve nutrient uptake and biomass production; it sometimes involves the application of very low doses of fertilizers (micro dosing) in countries of the semi-arid zone.

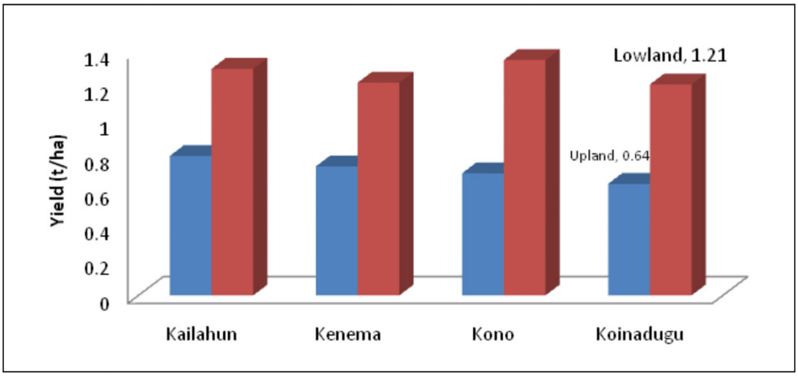
Agroforestry in various forms is practiced from the semi-arid to humid zone. In the semiarid zone it often involves *Faidherbia albida* which sheds leaves at the start of the rainy season thus improving soil organic matter. Other forms are boundary planting, dispersed inter-planting, fruit orchards and woodlots. Although the mitigation potential is relatively low with respect to emissions in the developed countries, agroforestry offers the potential of diversification of incomes of small scale farmers, increased crop yields and soil conservation in addition to carbon storage and is truly climate smart.

Intensive cultivation of lowlands in the sub-humid and humid zone results in increased production and productivity (WPF, 2008; Spencer, et al., 2009. Productivity is further increased where rain fed rice is followed by vegetables or a second crop of rice in the dry season under residual moisture or irrigation depending upon the characteristics of the swamps. Dry season cultivation exploits the abundant sunshine in the dry season and crops are less affected by insect pests and diseases. In addition to the production benefits, there are mitigation benefits because low land cultivation in Sierra Leone reduces the need to clear and burn upland vegetation.

Conservation agriculture benefits the soil even in the short run, but a major challenge is that farmers find manual planting of rice (the major staple in Sierra Leone) through mulch in uplands difficult (Danyi, 2012; Katta, 2012). Even though it results in increased yields over baseline levels, the yields are still low (Figure 4.1). Benefits in terms of crop yields from conservation agriculture are generally low during the initial years of implementation

Weather forecasting is another tool available in addition to the agronomic practices to combat the impacts of climate change in all countries but its development is highest in the CILSS countries. CCAFS together with the meteorological agency (ANACIM) developed, in a participatory manner with farmers, seasonal rainfall forecasts for small scale farmers in Senegal (Zougmore, 2014b). This aspect of climate risk management, provided in useful ways to farmers, facilitates decision-making in agriculture.

CCAFS (led by CIAT) in collaboration with NARES, NGOs and local authorities developed a model for improving adaptive capacity of farming communities in all agro climatic zones. Various CSA interventions are tested and validated in an integrated manner. The Climate Smart Village interventions are intended to be weather smart, water smart, carbon smart, nitrogen smart, energy smart and knowledge smart (CCAFS, 2013).



Source: FARA survey (2014); WFP (2008); IFAD (2010)

Figure 4.1 Rice yields in unfertilized and low fertilizer application in the uplands and lowlands of Sierra Leone

Note: Kailahun, Kenema and Kono districts (forest zone); Koinadugu district (savannah wood land zone)

Table 4.2 Biophysical and socio-economic circumstances under which CSA was proven

CSA Action	Agro Climatic zone	Land size	Land User	Land Owner	Soil Type	Terrain	Level of Mechanization	Skills/ knowledge	Labour
INTEGRATEDSOIL FERTILITYMANAGEMENT									
Micro dosing	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, Partly 2-5ha	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 SLOPEBARRIERS									
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 establish and 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	Semiarid	1-5ha	Small scale, Poor	Family, Individual	Low soil fertility	Flat to gentle	Mainly manual, partly Animal traction	Moderate	Moderate
LOWLAND RICE CROPPING									
Rice farming	Sub-humid, Humid	1-5ha	Poor, better off	Family, Individual	Low soil fertility, medium texture	Flat	Manual, power tiller	Moderate	Depends on standard of swamp develop-ment

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

Table 4.3 Adaptation and mitigation practises used in Burkina Faso, Senegal and Sierra Leone

	AEZ	CSA Practice	Potential Benefits		
			Production	Adaptation	Mitigation
Burkina Faso	Semi-arid-Sub-humid(Sahelian-Sudanian)	Short duration/drought tolerant crop varieties	++	++	
		Zai pits, stone bunds	++	++	
		Crop associations, rotations	++	++	++
		Use of low to moderate doses of farm nutrient inputs	+++	+	-
		Restoration of degraded lands	+	++	++
		Agroforestry(parklands)	++	++	+++
		Assisted natural regeneration	++	++	+++
		Cropping of lowlands	+++	++	+/-
		Composting	++	++	+
		Restitution of crop residues to the soil	++	++	++
		Cultivation on ridges	++	++	
		Vegetable cultivation and poultry raising	++	++	
		Cloud seeding	++	++	
		Control of herd size and mix	++	++	
		Transhumance	++	++	
		Seasonal weather forecasts, insurance	++	++	
Senegal	Semiarid to sub-humid(Sahelian-Sudanian)	Short duration/drought tolerant crop varieties	++	++	
		Cultivation of traditional crops e.g. sesame, fonio	+	++	
		Agroforestry(Parklands)	++	++	+++
		Assisted natural regeneration	++	++	+++
		Association of crops with Guiera senegalensis	++	++	+++
		Stone bunds	++	++	
		Moderate use of fertilizers; micro dosing	+++	+	-
		Integrated crop/livestock management	++	++	++/-
		Vegetable cultivation and poultry raising	++	++	
		Use of livestock breeds tolerant to heat stress	++	++	-
		Control of herd size and mix	++	++	
		Transhumance	++	++	
		System of Rice Intensification	+++	++	
		Seasonal weather forecasts, insurance	++	++	

	AEZ	CSA Practice	Potential Benefits		
			Production	**Adaptation**	**Mitigation**
Sierra Leone	Sub-humid-humid	Use of short duration /drought tolerant crop varieties	++	++	
		Changes in farming calendar	++	++	
		Fertilizer use	+++	++	-
		Swampland wet and dry season cropping	+++	++	+/-
		Intercropping, crop diversification	++	++	
		Vegetable cultivation and poultry raising	++	++	
		Conservation agric.(rotation, mulch, minimum tillage)	++	++	++
		Agroforestry	++	++	+++
		Multistorey tree crop farming	++	++	+++
		Processing of crop and livestock produce		+++	
		Raising of small ruminants	++	++	-

Notes: +slightly positive; ++moderately positive; +++very positive; -slightly negative

Source: FARASurvey (2014); CCAFS (2014)

5. Policies and Actions to Promote Climate Smart Agriculture

5.1 National policies

The overall national policy goal of these three Least Developed Countries is to make agriculture an engine of economic development and increase agricultural GDP growth to at least 6% in line with CAADP. Balanced growth in the subsectors was the traditional strategy but the recent trend in Burkina Faso and Senegal is to focus on high potential productive sectors (Burkina Faso, 2011; Senegal, 2011). The economies of Burkina Faso, Senegal and Sierra Leone are mainly liberalized; for example Sierra Leone removed subsidies on fertilizers in the 1990's which led to sharp drop in consumption of fertilizers by small scale farmers.

There are no specific policy documents on CSA in the three countries. However, documents on policy, strategy and plans related to climate adaptation, rural development, agricultural development and the environment exist. The documents analyzed (Table 5.1) are the National Adaptation Programmes of Action (NAPA's), National Communications to UNFCCC, National Agriculture and Food Security Investment Plans (NAFSIPs) and Poverty Reduction Strategy Papers (PRSPs).

National 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. The CSA factors considered in the analysis are: 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 (Kissinger, et al., 2013).

Burkina Faso

The NAPA is linked to development policies and programmes especially in terms of making a contribution to the Poverty Reduction Strategy. It was developed under the leadership of the Ministry of Environment and Water. A participatory approach involving policy makers, administrators, technical divisions of the Ministries, producers and NGO's was used.

The total cost of the 12 NAPA projects is US$ 5,896,884 of which US 2,199,884 (37.3 %) is for projects closely related or focused on agriculture and food security. There are no explicitly stated mitigation elements in the adaptation projects. All the adaptation projects have clear implications for food security. The Initial National Communication of Burkina Faso indicates that agriculture, in particular livestock, is the primary source of GHG emissions. Adaptation options envisaged include breeding of adapted crop varieties and diversification from cotton production.Gender was taken into account in the composition of the 'group of experts' who participated in the preparation of the NAPA. Gender was also one of the pre-selection criteria for the projects; however 67% of projects are intended to benefit men (Gonzalez, et al., 2011).

Table 5.1 National policies and programmes related to CSA

	National Adaptation Programme and Plan	Other Climate Change Policy or Planning Guidance	Agriculture or Development Policy, Strategy and Plan
Burkina Faso	National Adaptation Programme of Action (2007)	UNFCCC 1st National Communication (2001)	National Programme for the Rural Sector (PNSR) (2010)
			Strategy for Accelerated Growth and Development (SCADD) (2011)
Senegal	National Adaptation Programme of Action (2006)	UNFCCC 1st National Communication (1997)	National Strategy for Poverty Reduction (2006)
			Orientation Law on Agro-Sylvo-Pastoral Use (LOASP) (2004)
		UNFCCC 2nd National Communication (2010)	National Plan for Agricultural Development (PNDA) (part of LOASP) (2004)
Sierra Leone	National Adaptation Programme of Action (2007)	UNFCCC 1st National Communication (2006)	National Sustainable Agricultural Development Plan (2009)
		UNFCCC 2nd National Communication (2012)	Smallholder Commercialization Programme (2010)
			Agenda for Prosperity (PRSP) (2012)

Senegal

The preparation of the NAPA and UNFCCC Communications was under the leadership of the Ministry of Environment and Protection of Nature, in collaboration with central government, the National Committee on Climate Change, (COMNAC), Coordinating Agency, Climate Change and Natural Resources Management (NEPAD), Ecological Monitoring Centre (CSE), Universities, NGO's and the private sector.

The NAPA is linked to national objectives expressed in the PRSP and other income improvement and productivity programmes and decentralization policies. The adaptation/mitigation options include agroforestry, crop diversification, short duration crop varieties, varieties tolerant to salinity, water harvesting, wind barriers, anti-erosion devices, prevention of bush fires, fertilization, reorganization of the system of livestock raising and an early warning system. The agroforestry option incorporates mitigation elements but reduction of GHG emissions (mitigation) through, for example, organic fertilization and reduction of fertilizer use, for increased carbon sequestration and reduction of land degradation are considered as longer term options.

The need for research on desertification, water use, development of adaptable plant varieties and agroforestry is highlighted. Two of the three adaptation programmes focus on agriculture. The projects have clear food security goals. Women are recognized as one of the key groups of players in the implementation of the NAPA.

The Initial and Second National Communications point out the importance of bush fires and agriculture in contributing to GHG emissions and the negative effects of these practices on food production. Some of the recommended adaptation options - development of heat and salt tolerant varieties, fight against desertification, irrigation and use of moderate doses for fertilizers have elements of mitigation as well as anti bush fire education programmes.

Sierra Leone

The NAPA takes into consideration the existing Poverty Reduction Strategy Paper. The preparation of the NAPAs and Communications was done in a participatory manner under the Ministry of Transport and Aviation, in collaboration with the Climate Change Project Secretariat, the Environment Protection Agency, stakeholders from the Universities and the Agricultural Research Institute.

In the Initial National Communication, the mitigation options identified in the agriculture sector are crop residue application to soils, management of livestock manure, control of bush fires, research on nutrient composition of feeds and fodder and reduced use of pesticides. Both mitigation and adaptation measure are outlined in the Second National Communication but there is no recognition of the need for synergies rather than trade-offs between them. Policy support is recommended for the various adaptation measures. Adaptation options in the NAPA are in agroforestry, multiple cropping, crop diversification, seed banks, conservation tillage, contouring, irrigation, terracing, vegetative soil cover, water harvesting, change in planting dates, choice of varieties, planting density, row spacing.

Priority projects include development of irrigation and land drainage systems for agriculture; development of agricultural land use and land cover management and promotion of swampland farming. However only 3 of the 24 projects costing $3,395,000 (11% of the NAPA) focus exclusively on agriculture.

Concerning implementation of the NAPAs, all the countries are in the early stages and do not have detailed concrete plans consistent with an overall adaptation strategy (Kissinger, et al., 2013).

National Agriculture and Food Security Investment Plans

As part of their compacts with CAADP (NEPAD, 2003), African countries have developed NAFSIPs or NAIPs, all of which are currently being implemented. Assessment of these national agricultural investment plans for climate smartness is based on: potential contribution to adaptation and mitigation, production and productivity improvement, value chain enhancement, institutional support and consistency with NAPAs (Branca, et. al., 2012). Like for the NAPA's the level of participatory development and coordination and gender are also part of the analytical framework of this section.

Burkina Faso

The National Programme for Food Security 2011-2015 (PNSR) is the framework for operationalizing the Strategy for Rural Development (SDR) and the rural development aspect of the Strategy for Accelerated Growth and Sustainable Development (SCADD). The PNSR reflects the aspirations of CAADP and ECOWAP (Loada, 2014).

The process of development was participatory, involving government ministries, research institutions, farmer's organizations, and civil society, and private sector, technical and financial partners. The document recognizes that low productivity is due to climate and other factors and that low rainfall, especially its poor distribution as the principal barriers to increasing agricultural production.

Key adaptation/mitigation practices and approaches such as Sustainable Land and Water management including soil fertility restoration and management, management of pastures, markets and commercialization, research and technology dissemination and food and nutrition security of the most vulnerable are taken on board in the PNSR (NEPAD,2012). There is coherence between the crops subsector, livestock, water resources and environment subsectors (Loada, 2014).The PNSR does not specifically mention gender issues, but it is aligned with the SDR whose objectives include the improvement of the economic and social status of women and youth in the rural sector.

Senegal

Senegal's NAFSIP is titled National Agricultural Investment Plan (PNIA) 2011-2015. There is explicit recognition of climate change consequences. Sub programme 1 is on climate risk reduction through water control and most of the sub-programmes involve value addition and marketing. The sub-programmes/activities of the investment plan (merged into four strategic programmes mainly along the CAADP pillars) show a potential to contribute to food security, adaptation and mitigation (Branca, et.al., 2012).

The major sub-programmes and components of the PNIA are in line with the proposed activities of the NAPA. About 80% of PNIA costs are consistent with the NAPA priorities, namely agroforestry, water management, sensitization to natural resources management, and coastal preservation. The major criticism of the document is the heavy reliance on agrochemicals, which could have adverse effects on the environment (Branca, et. al., 2012). There, is coordination among the crops, fisheries, livestock, and environment and policy aspects thereby providing the right environment for climate smart agriculture.

Sierra Leone

The National Sustainable Agricultural Development Plan, 2010-2030 (GOSL, 2009), is Sierra Leone's compact with CAADP. The plan acknowledges that at the global scale, Sierra Leone contributes very little to global warming but is likely to be disproportionately affected by the impacts of climate change due to widespread poverty and limited adaptive capacity. It also recognizes the roles of gender and youth in agriculture. The Smallholder Commercialization Programme (SCP) 2010-2014 was developed from the Plan for implementation as the flagship programme of the Ministry of Agriculture, Forestry and Food Security. The components of the SCP include value addition and safety nets (risk management) and marketing. Programmes with the strongest adaptation synergies are those on production intensification, rural financial services and social protection. The number of programmes and activities with potential mitigation benefits is limited (Branca, et. al., 2012). In selecting beneficiaries, steps are taken to ensure that fifty percent of beneficiaries in key components are women and youth (SCP, 2010).

Poverty Reduction Strategy Papers

For CSA to thrive, there should be enabling policies and strategies beyond the agricultural sector for example on safety nets, energy, education, health, trade and national budgets. The essential elements of the framework used for the analysis are: having of a comprehensive overarching multi-sector approach in 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, planning and implementation, and gender considerations.

Burkina Faso

The comprehensive multi-sector Strategy for Accelerated Growth and Sustained Development (SCADD) 2011-2015 is based on a policy of focusing on developing the productive capacities of the Burkinabe economy, in line with 'Burkina 2025' (Burkina Faso, 2011). It was developed in a participatory manner, involving a range of stakeholders. It recognizes that Burkina Faso has a natural environment with limited potentials marked by variable and deteriorating climate. The overall objective of SCADD is to achieve a strong sustained and quality economic growth, generating a multiplier effect in terms of income generation, quality of life and sustainable development. The specific objectives are to contribute to the alleviation of extreme poverty and hunger and promote gender equality and empowerment of women to ensure environmental sustainability. The accelerated growth model adopted is based on policy that includes focusing on:

(i) Pro-poor growth to effectively fight poverty with respect to agriculture,
(ii) Land tenure security through effective implementation of the Land Security Policy and the National Strategy for the Integrated Management of Soil Fertility,
(iii) Implementation of the action plan for Agricultural Mechanization, and
(iv) Additional measures to adapt and mitigate the vulnerability of the sector to climate change such as agro-processing and marketing. The expected contribution of agricultural research to these activities is explicit. SCADD aims to strengthen programmes that reduce gender inequality making use of the National Gender Policy of 2009.

Senegal

The National Strategy for Economic and Social Development (NSESD) 2013-2017 provides the framework for intervention by government and its development partners in the various economic sectors including agriculture. It is driven by a policy of moving Senegal along the path towards an emerging economy in line with 'Senegal 2025' and the Agro-Sylvo-Pastoral Orientation Law which defines overall policy and an integrated framework for 2004-2024 for the development of the crops and livestock sectors. Its development was participatory. The overarching aim is to accelerate economic growth, and increase productivity. It puts emphasis therefore on the productive (for example agriculture) and production support sectors and on sectors with high- value creation potential. The comprehensive NSESD contains pillars on all the key sectors. The objective of the pillar on the agriculture sector is to increase production and productivity.

The need for more emphasis on irrigation, agricultural research and extension so as to reverse the fluctuating and downward trend in crop yields is highlighted. Another objective is the mitigation of the effects of climate change on ecosystems through control of bushfires, deforestation, and erosion control and land degradation. Gender mainstreaming in public policies for the fair participation of men and women in the development process is one of the strategies.

Sierra Leone

The vision of the Agenda for Prosperity 2013-2018: road to middle level income status (GOSL, 2013) is that Sierra Leone aspires to be an inclusive, green and middle income country by 2035. The document explicitly recognizes that climate change is one of the risks associated with implementation of the Agenda. The Agenda is comprehensive with pillars covering all the key development sectors. The pillars of the Agenda have components of CSA but there is no in- depth coverage of climate change issues.

The goal of Pillar 1 is a sustainable, diversified and commercial agricultural sector to ensure food self-sufficiency in major staples, food security, increased exports and creation of job opportunities for men and women. It is intended that these be done through improving land, woodland and water management in both uplands and lowlands by restoring natural capital through increasing vegetation and tree crop cover, restoring soil fertility and reducing erosion and making rain fed agriculture resilient to weather events, resulting in improved yields and household incomes. It also aims to empower women and girls by reducing socio-economic barriers and improving decision-making in the public, private and traditional institutions, access to economic activities and finance and capacity development. The Agenda states government's pledge to enact Equality Legislation and set up a National Women's Commission.

In summary, food security and adaptation concerns feature prominently in the documents analysed for all three countries. Mitigation activities are sometimes mentioned, for example, in National Communications, but it is not recognized that some adaptation activities also have mitigation effects. Two key aspects of a CSA enabling policy environment

(i) recognition of and accommodation of the multiple objectives of increasing food security, adapting to climate change and reducing emission and
(ii) creation of incentives for CSA (Lipper, 2014) are not clearly brought out in the documents. Decentralized implementation is generally through a series of committees from state to ministry to district to community levels involving public and private sector stakeholders. Mechanisms of implementation and coordination are specified in all the documents. The involvement of the Offices of Presidents and Prime Ministers in oversight roles demonstrates strong political commitment

5.2 Regional Policies Supporting CSA

ECOWAS

The sustainable improvement of agricultural productivity (a key pillar of CSA) has been a major concern of ECOWAS. The policy objective of its regional agricultural policy (ECOWAP, 2005), is to contribute in a sustainable way to meeting the food needs of the population, to economic and social development and to the reduction of poverty. It addresses the issues of sustainable intensification of agriculture through modernization and security of farm enterprises; promotion of agricultural food chains; management of shared resources; prevention and management of food crises and natural disasters and financing agriculture.

ECOWAS developed an Environmental Policy (ECOWAS, 2008) whose overall objectives are to reverse environmental degradation and depletion of natural resources, ameliorate the quality of the living environment and conserve biological diversity to ensure a healthy and productive environment. The strategic actions include promoting the monitoring of environmental change and the prevention of risks by setting up a Regional Centre Observatory, combating land degradation, drought and desertification and sustainable management of coastal, inland and marine ecosystems. Response to climate change was not one of the actions envisaged. Thus a Regional Action Program to Reduce Vulnerability to Climate Change in West Africa (ECOWAS, 2009a; 2009b) was adopted. It was acknowledged that while urgent priority measures in the NAPAs are worthy of continuation and support, it is also important to complement them with concerted adaptation options at the regional level.

The goal of the ECOWAS programme is to develop the required mechanism, actors and capacity to provide support to governments and communities as they adapt to climate change. The objectives are:

(i) regional institutions are politically, technically and financially supporting the states in their process to adapt to climate change;

(ii) national stakeholders in each country are adopting harmonized and coordinated approaches to adapting to climate change; and

(iii) climate change is mainstreamed into priority regional and multi-country investments, programmes and projects.

AU-CAADP Framework

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 harmonization and financing amongst partners as well as help African countries determine their agendas on agriculture/climate change and build informed leadership and responsibilities. It was intended as an integral component of the CAADP pillars (NEPAD, 2003) especially Pillar 1-Extending the area under sustainable land management and reliable water control. In general, the framework provides guidance to national and regional initiatives on programmatic approaches on knowledge generation, knowledge management and technology transfer and financing to scale up, 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 upscaling.

6. Existing Gaps and Investment Opportunities

6.1 The CAADP CSA Framework

The focus in this section is on the NAFSIPs which are the key instruments for rolling out the CAADP process. The gaps identified are outlined in terms of the AU-CAADP framework on agriculture, climate change adaptation-mitigation.

Gaps in Production and Commercialization
All the NAFSIPs focus on production, but crop and livestock yields are unstable and low, production has not kept pace with the demand of growing and urbanized populations. Commercialization, an important aspect of all NAFSIPs and for value addition is being promoted but external trade balance is negative in favor of developed countries, while regional trade is undeveloped. The ECOWAS protocols on free movement of goods and persons across borders are not fully implemented at national levels, for example, NRC (2010) reported harassment of traders by immigration, customs and police officers at border posts between Sierra Leone and its neighbouring countries. There is also inadequate information on import requirements of potential markets in West Africa.

Gaps in Adaptation-Mitigation Integration
The NAPAs and the NAFSIPs have emphasized short-term adaptation. The mitigation elements of adaptation programmes such as Sustainable Land and Water management are substantial but are generally not recognized in the country documents. 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. This attitude also reflects little recognition of the potential for synergies between adaptation and mitigation.

Gaps in Implementation of CSA at Various Scales
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 however 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. Adaptation and mitigation benefits may only be feasible if actions are taken across landscapes, for example, control of flooding in low lying areas depends on the adoption of sustainable land management practices in the uplands.

Gaps in Knowledge and Scientific Capacity to Improve Adaptation-Mitigation Response
In terms of knowledge priorities, the gaps are found in the following areas:

- Technical interventions and practices, for example sustainable intensification, crop diversification, conservation agriculture, ground water management and use and soil nutrient management; adaptation and mitigation in the livestock sector. Knowledge is also needed on modeling impacts of climate change on annual crops, tree

crops, integrated pest management and livestock. Concerning the later an IFPRI study (Jalloh, et al., 2013) showed differences between model predictions within Burkina Faso, Senegal and Sierra Leone.
- Evidence-base of CSA (which this FARA survey is intended to alleviate)
- Support services and extension for CSA
- Inclusive, integrated planning and monitoring of CSA.

The capacity for conducting strategic research by the national Agricultural Research Institutes in the three countries (INERA in Burkina Faso, ISRA in Senegal and SLARI in Sierra Leone) and their partner universities is low and they have to rely on CGIAR centers for strategic research. 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 loss of human capital was also immense.

Gaps in Policy and Capacity of Institutions to Formulate Policy

In general, there is limited or no involvement of policy makers in the agricultural research process and ineffective forms of communicating research results to policy makers and end users.

All countries are in the early stages of implementing their NAPAs 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 of a changing climate.

There is no policy support for climate risk management in terms of insurance schemes for farmers in Sierra Leone, but an entire programme of the SCP is on social safety nets. Weather indexed-based insurance schemes being developed as part of the Climate Smart Villages in Burkina Faso and Senegal will provide evidence for policy support for climate risk management.
Institutions responsible for agricultural policy in West Africa suffer from capacity gaps. The root causes of which include:

(i) lack of relevant data and data production capacities resulting in documents that are superficial or incomplete with errors of design attribution, and allocation
(ii) lack of skills in forecasting, strategic analysis, and ex-ante evaluation related to net benefits of investment options
(iii) legislative and regulatory frameworks and tools used for funding issues are usually not well known and
(iv) inconsistency between various regulatory authorities (Loada, 2014).

Gaps in Gender Parity

The AU-CAADP framework (CAADP, 2010) surprisingly does not focus on gender issues. However, national policy, and strategy documents in West Africa are increasingly taking into consideration gender issues but there is still much to be done in terms of women's strategic needs (decision making, control over finance, etc.). Although gender was taken into consideration in the composition of the 'group of experts' in the formulation of the NAPA of Burkina Faso, more projects (67%) benefit men and 33% both men and women (Gonzalez, et al., 2011). In the SCP of Sierra Leone, 50% of beneficiaries are required to be women and youth. Budgeting on the basis of gender is generally lacking in NAPAs and NAFSIPs; the NAFSIP of Senegal therefore stands out in including lines for gender and youth. Noting the weak gender mainstreaming in agricultural policies and CSA, FAO and other organizations have produced guides (BNRCC, 2011; FAO, 2012). The extent to which they are being effectively utilized is unknown.

Gaps in Finance

Externally funded expenditure as a percentage of total agricultural expenditure has been high. For Burkina Faso, it was 20% in 2001 and 18% in 2005; for Sierra Leone, it was a very high 82% in 2009 and 71% in 2011 (ISO, 2014). The NAFSIPs in all countries have large gaps in funding and are heavily reliant on donor funds. Although there is a wide range of estimates, both adaptation and mitigation actions required for future agricultures are projected to lead to significant increases in need for 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 many industries in Least Developed countries are fledgling, it is difficult for them to perceive their role, as part of private sector, in contributing to GHG emissions and therefore contributing to financing of CSA research.

AU-NEPAD (2010) drew attention to the need to avoid the complex and fragmented sources and mechanisms for funding climate change adaptation-mitigation. Mobilizing adequate funds to address CSA requires innovation and political will. The CAADP framework focuses on higher level financing issues and is characterized by the following:

- Developing/adapting and providing to countries and regional initiatives, instruments and capacity building support to engage and negotiate at global level for financing.
- Targeting and facilitating direct engagement and access to:
  (i) multilateral and bilateral aid
  (ii) direct foreign investments and local private financing and
  (iii) special instruments for public-private co-financing.
- Providing capacity building in:
  (i) management, budgeting, disbursement, accounting and auditing
  (ii) strengthening deployment of resources and systems fo accountability
  (iii) ensuring local public sector financing that provides the core base in leveraging and aligning development aid and private sector financing.

The framework will ensure effective mechanisms for revenue generation and disbursement for the various financing modalities and delivery mechanisms.

6.2 Country Specific Gaps

Burkina Faso

Budget allocation to the rural sector between 2006-2010 averaged about CFA 136.5 billion, that is approximately 14 % of the national budget (CFA 975 billion). Eighty six percent of this went to the Ministry of Agriculture and Water, 8% to the Ministry of Animal Resources (Burkina Faso, 2011). Allocation to agriculture stabilized at 13.5% in 2009 and 2010 (Loada, 2014). The Maputo Accord of 2003 in which heads of African governments agreed to allocate at least 10% of their annual budget to agriculture by 2008, was therefore achieved. However, 80% of the financing of the rural sector is from external sources (Burkina Faso, 2011). The total cost of the PNSR is estimated at CFA 1230 billion for 2011-2015, that is 16.41% of the SCADD. Government and local communities contribution was 31% of the total (Loada, 2014). The financial gap was estimated to be CFA 364.74 billion, that is 30% of the total budget.

Senegal

As far back as 2004, Senegal was allocating about 10% of its budget to agriculture. It increased to about 12% in 2005, fell back to 10% in 2006 and rose to 11% in 2007 (CAADP, 2009). The cost of the PNIA is CFA 1346 billion. The budget is very detailed and indicates line items for women and youth. The finance gap for crops, livestock, and environment subsectors are 35.2%, 95.5%, 71.2% respectively. Government contribution was 32% of the budget and the aggregate funding gap estimated at 50% of the budget (Senegal, 2011).

Sierra Leone

Allocation from the government budget to agriculture rose significantly over the past few years; it was only 3.81% in 2009, rose sharply to 7.55% in 2008 and to 8.87% in 2009, fell back to 6.16% in 2010 and again rose to 7.96% in 2011 and fell to 6.6% in 2012 (IOS, 2014). However, Sierra Leone has never attained the 10% allocation to agriculture required by the Maputo accord (EDS, 2013). The total budget of the SCP is $378 million. The biggest allocation is to Social security and safety nets - $135 million (36% of the SCP). Government's contribution is estimated at only 5-6 % of the budget and the funding gap is 50%.

7. Key Drivers for CSA Adoption

7.1 Drivers for Promoting CSA

The underlying drivers of scaling up of CSA in the region include appropriateness and profitability of CSA technologies; approach to technology dissemination (iterative and participatory learning such as Farmers Field Schools (FFS); communication and information between stakeholders; capacity building of stakeholders in CSA; social capital of farmers; access to land, credit, inputs and markets by farmers; gender equity; strong government support both for policy in support of CSA and elaboration of scaling up frameworks; overall national economic environment, as well as finances from multiple sources and incentives for farmers. All stakeholders should be made aware of the identified drivers of scaling up and out and encouraged to take the appropriate actions to optimize benefits. For example, incentives such as food for work, fertilizer voucher schemes, access to credit and markets and assistance to community groups should be provided by governments and NGOs. Governments and NGO's should provide weather forecasts to farmers 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; if possible, on a landscape (micro-catchment) basis should be strengthened. NARES should develop strong linkages with AU-CAADP, ECOWAS, FARA, CORAF, and Regional Centres of excellence (ACMAD, AGRHYMET) and CGIAR centres such as ICRISAT.

7.2 Challenges/Constraints in Implementing CSA

Scaling up and out CSA practices while recognizing that CSA interventions and practices are context-specific (FAO, 2014) is a challenge in itself. Challenges specific to the upscaling and out scaling of Best Bet technologies are shown in Table 7.1.

There are broad challenges that more or less cut across the three countries; these are technology generation, access to credit and markets, land tenure, knowledge and institutional gaps, research policy-linkage and policy. They have been discussed in earlier sections of the report. Challenges associated with land tenure and policy are highlighted here.

Land Tenure

At the community level, there are several human, social, and economic challenges. Traditional systems of inheritance and ownership of land have consequences for the adoption of 'investment technologies', involving planting of trees, construction soil and water conservation structures that would be expected to give return 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. 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. Some governments for example that of Sierra Leone have so far found it difficult to satisfactorily carry out land reforms to the satisfaction of both private entrepreneurs and rural folk.

Table 7.1: Technology Specific Challenges

Technology	Challenges
Integrated Soil Fertility Management (ISFM) - micro dosing	Profitability; access and availability of inputs; access to financial services; access to markets and infrastructure; awareness raisingand promotion; training/knowledge; incentives for example feasibility of group purchasing of fertilizers; secure land rights; rural infrastructure.
Conservation Agriculture - minimum tillage and direct planting	Immediate benefits; farm inputs for example machinery; secure land rights; training and capacity building; innovative participatory learning approaches; incentives for example food for work; access to markets; research.
Water Harvesting - zai pits	Profitability, secure land and water rights, market access; capacity building and knowledge sharing; incentives for example food for work for the high initial labour requirement.
Cross Slope Barriers - stone bunds/vegetative strips	Substantial yield gain; awareness raising on losses due to run off and erosion; access to training and knowledge; access to microcredit finance; access to inputs; labour requirement; loss of land; incentives for example facilitation of transport of stones, payment for ecosystem services.
Agroforestry - parklands; farmer managed natural regeneration	Traditional knowledge needs to be tapped and built upon; understanding of how the system works in different environments; knowledge system that documents experiences and facilitates exchange between practitioners and scientists; incentives in the form of land tenure reforms, markets for multipurpose tree products and payment for ecosystem functions.
Lowland Rice Cultivation	Secure land tenure; high yielding rice varieties, plastic rice varieties for under-developed swamps, fertilizers and water control for intensive cultivation.

Source: Lineger et al. (2011)

Policy

It was observed earlier that climate adaptation programmes are usually separate from agricultural development policies, plans and programmes. Policy contradictions may occur because of failure to recognize and manage tradeoffs when CSA is not aligned with agricultural policies and when subsector sector policies are not aligned, for example, crops and livestock 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 vital importance of research, as part of overall agricultural policy is still not adequately recognized.

8. Creating Enabling Environments for Adoption of CSA

8.1 Encouraging Farmers to Adopt Climate-Smart Practices

There are many opportunities for CSA worth considering at the continental, regional and national levels. Food security is a major concern in the agendas of international organizations, national poverty reduction strategy papers, and agricultural development and investment plans of the three countries. There is increasing awareness of the impacts of climate change on agriculture and the need to respond in appropriate ways by AU, FARA, and CORAF 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 research and extension institutions and backstopping the scaling up and out of CSA. The CORAF policy of funding research and development projects jointly developed and implemented by at least 3 countries and the existence of broad agro-ecological zones, soil types and farming systems that cut across some countries also facilitates scaling up and out.

Existing knowledge and experience with CSA for example the CCAFS Climate Smart Villages in Senegal and Burkina Faso and existence of guidelines on climate change and gender mainstreaming targeted at governments and practitioners of CSA (FAO, 2012) are good opportunities. Community level approaches and guides to adapt to climate change developed by ENDA (Ampomah and Devisscher, 2013), tools on integrating gender into CSA (BNRCC, 2011) and availability of Best Bets are all key opportunities. Existing national frameworks for implementing NAFSIPs and PRSPs which are well set up and in line with government policies of decentralization of certain functions to district levels could also be used to encourage farmers to adopt CSA.

There are national farmers associations and regional farmer's association (ROPPA) playing advocacy roles on behalf of 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 is also opportunities for CSA. That farmers (producers) are now aware of their vulnerability to the effects of climate change and are already adapting should also be considered as an opportunity.

It is an established fact that adequate and sustained financing is fundamental for CSA to be widely adopted by small scale farmers and to be scaled up and out. This 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 building on.

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) will also facilitate funding of CSA.

8.2 Gender Considerations with Regards to Climate Change Impacts, Adaptation and Use of CSA Practices

Evidence from Burkina Faso, Senegal and Sierra Leone is that women and youth are the most vulnerable to climate change because of their subordinate roles in rural communities. Men dominate decisions making on production of the cereal staples and incomes from rice value chains in Sierra Leone (de Hoogh, et al., 2011). Involvement in decision making is further decreased as climate change imposes additional workload on women which prevents them from active participation in community life. The role of women and youth is mainly to provide farm labour, care for the sick and elderly, prepare food and fetch firewood and water.

Women and children are also particularly susceptible to malnutrition and disease (IFAD/GOSL, 2010) and women-headed households are the most food insecure in Sierra Leone (WFP, 2008). Climate change that leads to shortage of water resources, soil degradation and low harvests means that more pressure is put on women. For example, in Keur Moussa located between Dakar and Thies in Senegal (WEDO, 2008) women are unable to grow off-season vegetables, access to good quality land is reduced and with little savings, or cattle to serve as collateral, access to credit becomes more difficult, if not possible.

Adaptation and gender roles and responses are differentiated for example, men in Senegal help women and girls to improve 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. Conservation agriculture, a CSA practice involving minimum tillage may reduce labour requirements for land preparation (normally the responsibility of men in Sierra Leone), but weed control without use of herbicides may lead to shift in labour from tillage to weed control, a task usually done by women (Giller, et al., 2009). As an adaptation strategy to climate change, men and youth migrate from villages and women are left to fend for themselves; for example in the village of Landou in Senegal, WEDO (2008) reported a population of 118 women and only 20 men. Nielson and Reenberg (2010) reported that in a village in Northern Burkina Faso, culture is a barrier to adaptation in terms of women being restricted in economic activities and livelihood activities that are traditionally defined.

NGOs in Senegal have provided assistance to women in controlling run off and soil erosion and thereby retain water, rehabilitate land and improve agricultural yields. For example, a successful soil and water conservation project (Agrobio Niayes Programme of ENDA-Pronat) implemented in the villages of Santhie Serer, Kessoukhatte and Landou in the Niayes region of Senegal involved the active participation of women in the Anti-erosion Committee (decision – making) as well as in the active installation of the devices (WEDO, 2008). However, men and women do not generally benefit equitably from climate change adaptation programmes, which are often more targeted at men than women because 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. Adaptation measures in Burkina Faso designed for women do not apply a gender-based approach consistently. Failure to take gender into account may result in increasing work load of women (Gonzalez, et al., 2011).

Such an outcome, no matter how well intentioned shoud be considered as malladaptation.

9. Conclusion and Recommendations

9.1 Factors and Variables Related To the Adoption of Climate Smart Agriculture

There are significant gaps in production and commercialization, adaptation-mitigation integration, implementation of CSA at various scales, institutional capacity, knowledge, policy and financing. Studies on the impacts of climate change on livestock are inadequate and few models deal with livestock and none deal with heat or water stress effects. Also, integration of adaptation and mitigation into policy and practice and mainstreaming of climate change issues into agricultural development are lacking. Already, there are serious financial gaps in the funding of NAPAs and NAFSIPs even without CSA incorporated into them.

The baseline factors, variables and indicators of success should be used with other indicators developed in a participatory manner with stakeholders, at the farm, community and national levels and be used to monitor and evaluate CSA interventions of FARA. The process should include development, with communities, of systems of locally relevant success indicators including productivity, capacity building and service related interventions and institutional outputs and outcomes. Because of the variable annual crop yields recorded over the past 10 years, appropriate experimental designs should be used to facilitate interpretation of crop response to CSA practices. Efforts should be made to stabilize crop yields and improve food security.

9.2 Successful Climate Smart Agricultural Practices for Scaling Up and Out

The drivers of scaling up include appropriateness and profitability of CSA technologies; approach to technology dissemination; communication and information; capacity building in CSA; social capital; 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. There are 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 are opportunities for CSA.

The following practices should be upscale 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 measures such as seasonal weather forecasting, index based insurance and safety nets should be scaled up and out. This would include the community-based participatory climate smart village approach involving climate risk management. Upscaling and out scaling should be done on the basis of agro-ecology, soil types and farming systems. At the administrative level, use should be made of the decentralized government structures to promote CSA in all sectors.

9.3 Policies that Promote Climate Smart Agriculture

AU-NEPAD and ECOWAS policies and programmes recognize the threats posed by climate change and need for adequate responses but there are no specific regional or national policies promoting CSA. The National Food Security and Investment Plans are the flagship undertakings of the various Ministries of Agriculture; all have elements of CSA but they do not explicitly promote it. They are being satisfactorily implemented within decentralized government structures.

Enabling the policy environment for CSA to thrive should be developed 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, energy, education, 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 such as women, the disabled, the elderly and the youth;

(vii) improved access to information and knowledge from institutions that generate knowledge;

(viii) promotion of climate risk management (insurance, weather forecasting, social safety nets) to cope with risks associated with climate change and adopting new practices.

Interventions should be made to reduce or eliminate the gaps in the priority areas identified within the CAADP framework in section 3.5. Some examples are as follows: Capacity building efforts should include study tours, workshops, seminars organized by FARA and CORAF/WECARD that will bring together research and extension staff, policy makers and civil society. Also recommended are conducting of farmer-based participatory experimentation and complementation of indigenous knowledge with scientific know- how. Use should be made of existing guides and tools on community-led approaches to adaptation to climate change.

Concerning the link between trade and food security, unofficial trade restrictions should be removed between countries and trade promotion agencies such as SLIEPA should lead dissemination of information on import requirements of potential markets in West Africa countries.

AU-NEPAD through the CAADP process should strengthen its support to governments to enable them access funds from existing and new sources to promote CSA. Assistance from philanthropic foundations should be sought. Governments should invest in national research institutes, universities and ministries of agriculture. The private sector for example lottery companies, commercial banks, importers of food stuff should contribute to CSA. Local communities should do their own bit by embarking upon self-help schemes but they will have to be convinced of the benefits that can accrue from investment in CSA.

9.4 Priority Crops and Livestock That Are Suitable for CSA Practices in the Different Agro-Ecologies

Various crop species and varieties are impacted by climate change to different degrees and therefore vary i n contribution ta daptability. The current situation is that positive responses (field trials and modeling) to CSA components have been reported for crops such as millet, sorghum, groundnut, rice, maize (mainly semi-arid / sub-humid zones), maize, rice, groundnut and cassava (mainly sub-humid/ humid zone), which are the important food and cash crops in the countries studied. At present, there are so called men's and women's crops (vegetables) in all three countries, with more importance given to male crops in adaptation projects, but since the fundamental objective of the CSA approach is to improve agricultural productivity while increasing resilience and reducing GHG, CSA must be beneficial for a range of potentially productive cropping systems including tree crops.

Little information is available on the response of livestock to CSA. Cattle are most important in the economy of countries in the semi-arid zone, and small ruminants and poultry are important in all zones. Livestock combining productivity and hardiness are suitable for CSA.

Positive responses to CSA practices have been reported for major crops such rice, maize, millet, sorghum and groundnut but this should not be interpreted to mean that they are the only "crops suitable for CSA". A wide range of crop species are suitable for the CSA approach. For example, tree crops are important in the context of agroforestry systems as components of CSA and for income generation. Nevertheless, priority should be given to the staple food crops in the promotion of CSA.

For any given crop species, varieties that are high yielding, resistant or tolerant to abiotic and non-abiotic stresses are most suitable for CSA. The CGIAR centers in collaboration with national agricultural research institutes have developed high yielding, disease tolerant varieties of many crops. For example, the Africa Rice Center has developed and promoted, (in partnership with National Agricultural Research Institutes) high yielding, short duration, weed competitive New Rices for Africa (NERICA) for a range of agro ecologies that permit rain fed double cropping within the upland colluvial - foot slope continuum. CIMMYT and IITA have done the same for high yielding short duration, drought and heat tolerant varieties of maize. These varieties should be promoted as integral components of CSA packages.

Cassava was traditionally an important crop only in the humid zone of West Africa, but with the development of improved varieties by IITA, its cultivation has spread to the drier agro ecological zones of West Africa including Burkina Faso and Senegal. It is resilient to future climate change and its cultivation could be an important adaptation option.

Local breeds of livestock are more tolerant to heat stress and drought compared to exotic breeds; cross breeds would combine productivity and hardiness. There is some evidence that coat colour of small ruminants may be a contributing factor to tolerance to heat and so selection for coat colour would be climate smart.

9.5 Gender in Agricultural Development and Climate Smart Agriculture

Women in rural communities of the three countries are particularly vulnerable to climate change because they are marginalised and disadvantaged. Gender is being taken into account in developing responses to climate change, but the efforts do not go far enough in terms of strategic interests (decision making and control ownership over assets and incomes).

The following should be done: (i) mainstream gender issues into agricultural development and climate change policies and programmes (ii) promote the amendment of laws or by-laws to improve women's access to land ownership (iii) create awareness raising programmes on CSA within communities and among those involved in rural development at local, regional and national levels (iv) promote women's access to agricultural extension services and training, credit and the inputs (v) promote access of women farmers to information about climate change, including weather forecasts (vi) promote women's access to CSA techniques (vii) strengthen women's organizations in rural communities and support their participation in the diagnosis of needs, planning, implementation and evaluation of CSA measures (viii) promote active participation in community decision making.

9.6 Conclusion

The level of poverty and food insecurity in Burkina Faso, Senegal and Sierra Leone is high and human development, agricultural production and incomes are low and external trade balance negative. Adaptive capacity of small-scale farmers to respond to climate change is low. The variability of annual acreage harvested, yield and production of major food crops suggests a need for careful projections and interpretation of crop responses to CSA practices, in the context of a multi-stressor environment. This poses challenges for development planning by governments of the three countries.

CSA in its true comprehensive form is not yet farmer's practice; rather elements of CSA are being implemented in all three countries studied. Many were developed initially for the purpose increasing agricultural productivity and protecting the natural resource base. There are components CSA practices in Burkina Faso, Senegal and Sierra Leone that are gaining wide popularity. They all have goals of improved production/ food security, adaptation and mitigation and Management and risk management.

9.7 Recommendations

A range of stakeholders working in a coordinated fashion is required for successful CSA. They include donor organizations, continental and regional research and development organizations and economic and political bodies for example (NORAD, AU, FARA, CORAF, CGIAR, ACMAD, AGRHYMET and ECOWAS), extension services of governments and NGOs, national research institutions, private sector, community and farmer based organizations and individual farmers. Recommendations aligned to the specific objectives of the survey are presented below, and a concluding statement.

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ANNEXES

ANNEX 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

ANNEX 2: List of Contacted Persons

Mr. Andrew Katta	CARE (Non-Governmental Organization), Sierra Leone
Mr. Olu John	President National Farmers Federation of Sierra Leone
Mr. Prince Kamara	Programme Manager, Smallholder Commercialization Programme, Ministry of Agriculture Forestry and Food Security, Sierra Leone
Dr Abdulai Jalloh	CORAF, Senegal
Dr Ibrahima, Diedhiou	Ecole Nationale Superieure d'Agriculture. University of Thies, Senegal
Mrs. Farma Ndiaye	CORAF, Senegal
Dr Francois Lompo,	Institut de l'Environnement ET Recherches Agricoles (INERA), Burkina Faso
Dr Leopold Some	Burkina Faso
Mrs. Fanta Diallo	Burkina Faso

ANNEX 3: Trends in Socio-Economic andAgricultural contexts

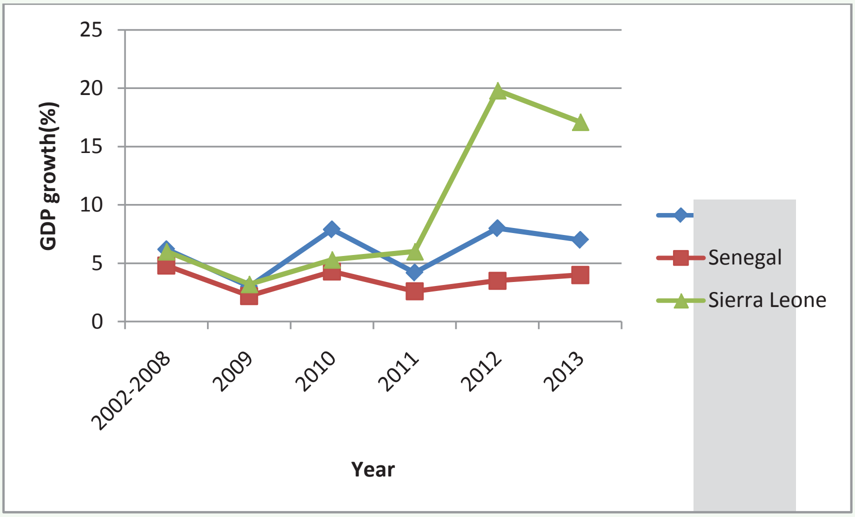

Figure 1: Changes in GDP Growth for Burkina Faso, Senegal and Sierra Leone

Source: IFPRI (2013)

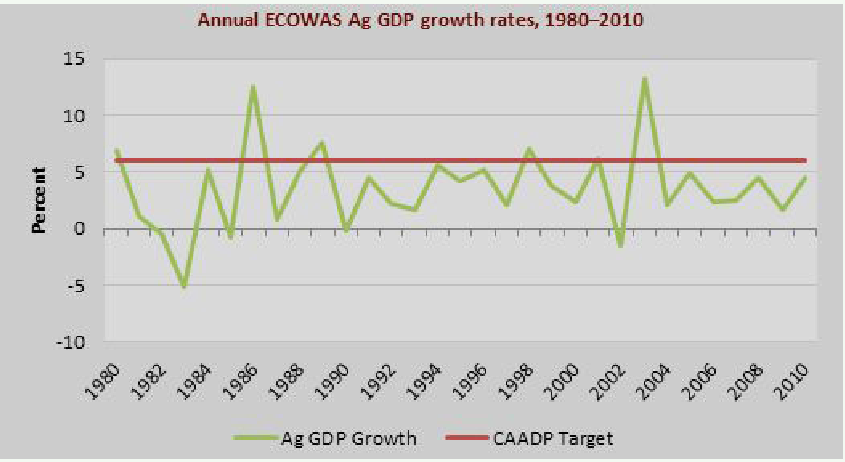

Figure 2: Changes in agricultural GDP growth in West Africa

ANNEX 3: Trends in Socio-Economic andAgricultural contexts

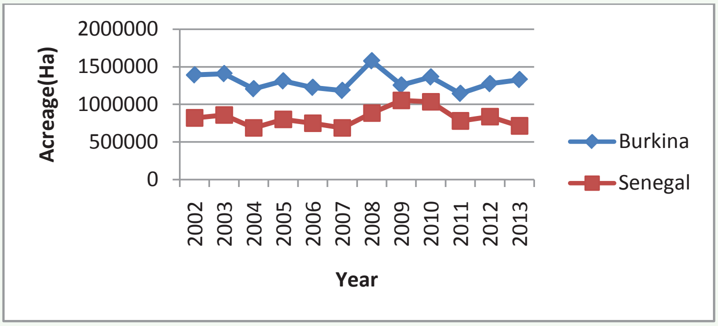

Figure 3: Changes in acreage of millet harvested in Burkina Faso and Senegal

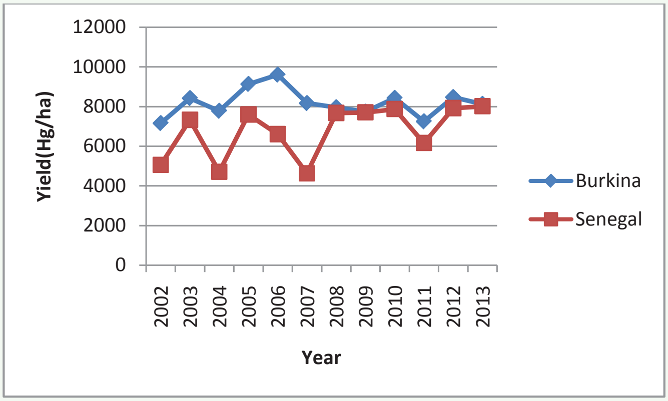

Figure 4: Changes in yield of millet in Burkina Faso and Senegal

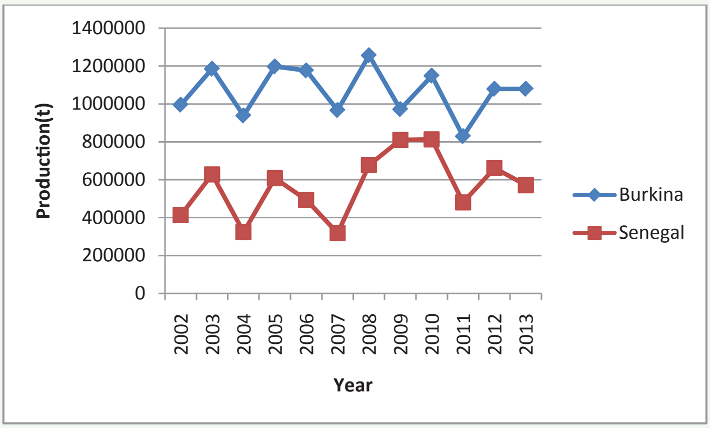

Figure 5: Changes in production of millet in Burkina Faso, and Senegal

APPENDIX 3: Trends in Socio-Economic andAgricultural contexts

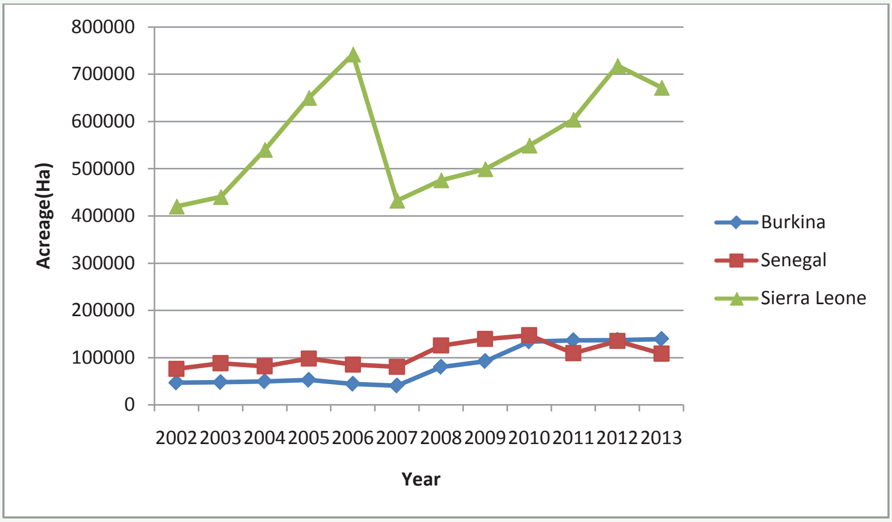

Figure 6: Changes in acreage of rice harvested in Burkina Faso, Senegal and Sierra Leone.

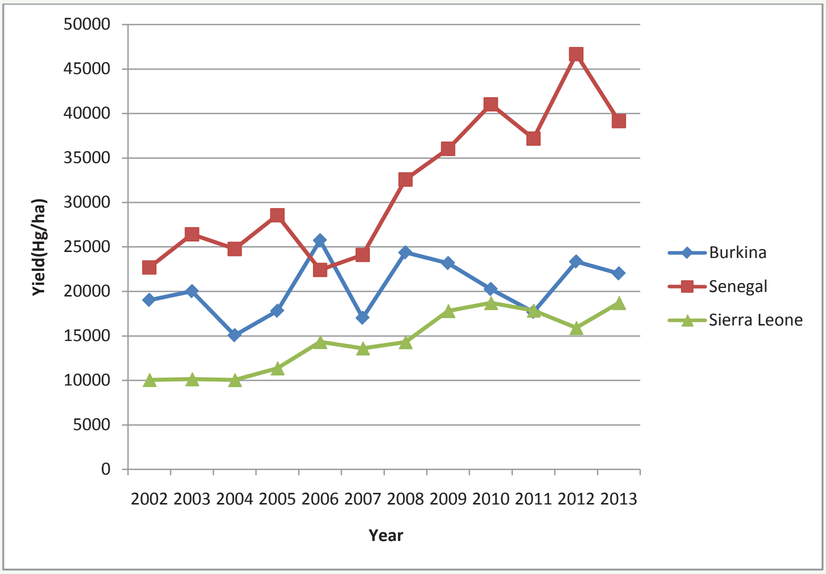

Figure 7: Changes in yield of rice harvested in Burkina Faso, Senegal and Sierra Leone.

APPENDIX 3: Trends in Socio-Economic andAgricultural contexts

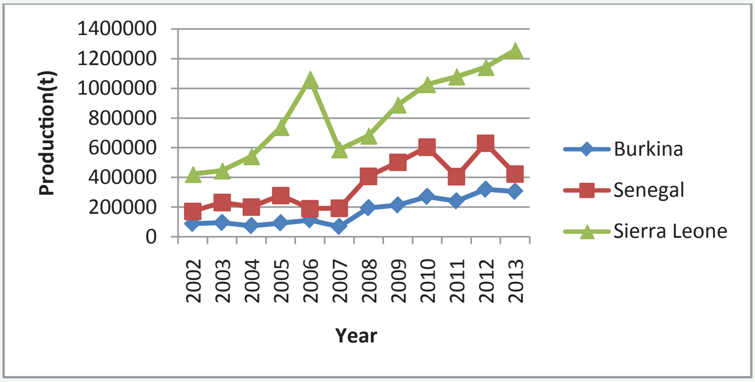

Figure 8: Changes in production of rice in Burkina Faso, Senegal and Sierra Leone

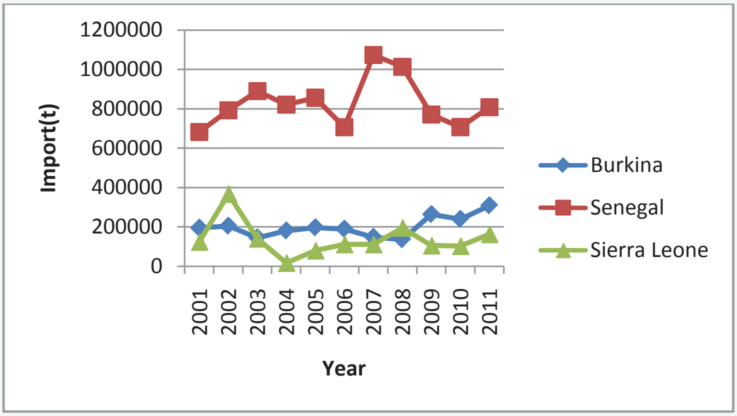

Figure 9: Changes in rice imports (tonnage) into Burkina Faso, Senegal and Sierra Leone

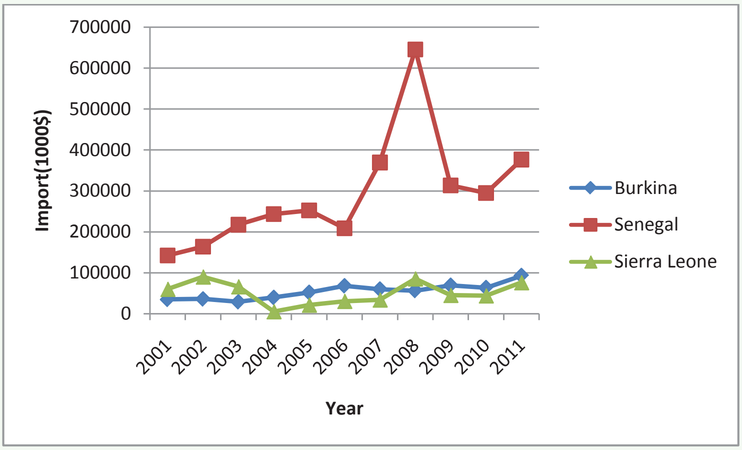

Figure 10: Changes in imports of rice (value) into Burkina Faso, Senegal and Sierra Leone

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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