Barriers to scaling up/out climate smart agriculture and strategies to enhance adoption in Africa

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

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List of Acronyms

ALP:	Adaptation Learning Programme for Africa
AEZ:	Agro-ecological Zone
AWM:	Agricultural Water Management
CA:	Conservation agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
CARE	Christian Action, Research and Education
CBA:	Community Based Adaptation
CCA	Canadian Climate Centre
CaLas	Carbon Credits for Sustainable Land use Systems
CSA:	Climate Smart Agriculture
CSR	Corporate Social Responsibility
GDP	Gross domestic product
CSA	Climate Smart Agriculture
ECA	Economic Commission for Africa
ESA	European Space Agency
FAO	Food and Agriculture Organization of the United Nations
FAO EPIC	Economics and Policy Innovations for Climate-Smart Agriculture
FARA	Forum for Agricultural Research in Africa
FDI	Foreign Direct Investment
GIZ	German: German Society for International Cooperation, Ltd.
GNI:	Gross national Income
GM	Genetic Modification
HoA	Horn of Africa
ICT	Information and communications technology
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country

MDG	Millennium Development Goal
MICCA	Mitigation of Climate Change in Agriculture
NAIP	National Agricultural Investment Plan
NAPA	National Adaptation Programme of Action
NAMA	National Appropriate Mitigation Actions
NEPAD	New Partnership for Africa’s Development
NGO	Non-governmental organisation
NORAD	Norwegian Agency for Development Cooperation
ODA:	Official Development Assistance
PCM	Parallel Climate Model
SLM	Sustainable Land Management
SMART	Specific, Measurable, Achievable, Realistic, Time Bound
SSA	Sub-Saharan Africa
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture
WHO	World Health Organisation

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Foreword

Climate change and variability are emerging as the major threats to development across the continent impacting adversely on agriculture and livelihoods. Similarly, Africa's population continues to grow with an estimated annual growth of 2.4% and the population is predicted to double from its current 0.9 billion people by 2050. According to the Food and Agriculture Organization of the United Nations (FAO), more than a quarter of Sub-Saharan Africa's people are currently undernourished. Crop production needs to increase by 260% by 2050 to feed the continent's projected population growth. Thus Africa's agriculture must undergo a significant transformation to meet the simultaneous challenges of climate change, food insecurity, poverty and environmental degradation. Climate-smat agricuture should be part of the solution in addressing this problem.

Climate-smart agriculture includes practices and technologies that sustainably increase productivity, support farmers' adaptation to climate change, and reduce levels of greenhouse gases. It can also help governments to achieve national food security and poverty reduction goals. Climate-smart approaches can include many diverse components from farm-level techniques to international policy and finance mechanisms. Many innovative climate-smart agriculture practices take place in Africa with the capacity to increase productivity and build resilience. Yet they remain largely unknown at the continental, or even regional and national levels. These good practices are not only unknown, but their wide-scale adoption remains a challenge especially amongst smallholder farmers in Africa.

There are several barriers that prevent smallholder farmers in Africa from adopting CSA practices and technologies and so far, existing policies and actions to remove these barriers remain inadequate. A good understanding of what these barriers are and how they impinge on adoption of CSA practices is essential. Equally essential are actions that favor the removal of these barriers, while at the same time promote adoption of CSA practices. This study report attempts to identify the barriers and strategies to enhance adoption of CSA practices. These barriers can be classified under two broad categories. The first relates to the physical means or resources required to practice CSA. These can be considered as the hardware barriers and include physical inputs such as land, human resources, equipment, infrastructure and finances. The second, referred to as the non-physical or software barriers, relates to the institutional, cultural, policy and regulatory environment; information, knowledge and skills; technologies and innovations; and governance among others.

For farmers to take up a particular CSA practice and for public and private sector individuals to invest in a given CSA practice, the barriers must be seen not to exist. An identification and critical analysis of the factors that limit adoption of CSA practices and actions that will enable policy makers to come up with concrete actions to scale up/out adoption of CSA practices in Africa is what this report has addressed. This report also outlined policy recommendations to promote the adoption of CSA practices in Africa.

Yemi Akinbamijo
Executive Director, FARA

Executive Summary

The world's climate is changing and will continue to change until drastic action is taken to combat the effect of climate change on human livelihoods especially in Sub-Sahara Africa where capacities to cope are limited. The risks associated with these changes are real but highly uncertain. Societal vulnerability to the risks associated with climate change may exacerbate ongoing social and economic challenges, particularly for those parts of societies dependent on resources that are sensitive to changes in climate (rain fed agriculture). Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural populations in Sub-Sahara Africa.

Many actors are promoting key agro-ecological farming technologies and practices that are highly suited to enable farmers to adapt to climate change. These include agro-forestry, crop rotation, intercropping, minimum tillage, soil cover maintenance, residue retention, water conservation, rice systems that reduce methane emissions, improved management of livestock and soil carbon as well as breeding plants and animals adapted for future climate conditions. These practices have been documented to generate higher and more stable crop yields and incomes and enhance resilience to climate change in some countries compared to conventional agricultural production methods. Although these practices are not necessarily new, when used in the context of climatic change, they have been proved to be innovative for farmers, herders and fishermen. Such practices are dubbed Climate Smart Agriculture (CSA). Wide-scale adoption of CSA practices however, remains a challenge especially amongst smallholder farmers in Africa.

There are several barriers that prevent smallholder farmers in Africa from adopting CSA practices and technologies and so far, existing policies and actions to remove these barriers remain inadequate. A good understanding of what these barriers are and how they impinge on adoption of CSA practices is essential. Equally essential are actions that favour the removal of these barriers, while at the same time promote adoption of CSA practices. These barriers can be classified under two broad categories. The first relates to the physical means or resources required to practice CSA. These can be considered as the hardware barriers and include physical inputs such as land, human resources, equipment, infrastructure and finances. The second, referred to as the non-physical or software barriers, relates to the institutional, cultural, policy and regulatory environments; information, knowledge and skills; technologies and innovations; and governance among others. For farmers to take up a particular CSA practice and for public and private sector individuals to invest in a given CSA practice, the barriers must be seen not to exist. An identification and critical analysis of the factors that limit adoption of CSA practices and actions that will enable policy makers to come up with concrete actions to scale up/out adoption of CSA practices in Africa is what this report has addressed. This report has also outlined policy recommendations to promote theadoption of CSA practices in Africa.

Many national governments across Africa are developing agricultural plans that focus on, or integrate climate change, namely Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Programmes of Action (NAPAs) and National Agricultural Investment Plans (NAIPs). In many cases, these plans have not featured climate smart agriculture practices as mechanism for addressing issues on climate change and variability. Early Warning Systems (EWS) are critical for monitoring major uncertainties when making decisions regarding the bio-physical, management and ecological barriers to adoption of CSA. Successful CSA practices at farm, landscape and entire food system levels are essential to be up and out-scaled,

Section One

1.0 Introduction

In spite of the development of several Climate Smart Agriculture (CSA) technologies and the positive gains arising from those technologies, wide scale adoption of CSA practices remains problematic in Africa. There are several barriers that prevent smallholder farmers in Africa from adopting CSA technologies and so far, existing policies and actions to remove these barriers remain inadequate. A good understanding of what these barriers are and how they impinge on adoption of CSA practices is essential. This report identifies barriers to scaling up/out climate smart agriculture practices and proposes strategies and practical actions to remove the barriers and enhance adoption of CSA in Africa. Section one of the report provides the background, rationale and objectives. Section two presents the African context of climate change and climate smart agriculture. Section three identifies and discusses the barriers that limit scaling-up and out of CSA practices. Section four outlines a number of strategies and practical actions to remove the barriers to adoption. Conclusions and recommendations are presented in Section five.

1.1 Background

Agricultural production and productivity depend on the genetic characteristics of crops, fish, forests, livestock, soils, conducive climate and the availability of needed nutrients and energy (bio-physical). Agricultural production and productivity further depend on people, values, goals, knowledge, resources, monitoring opportunities and decision making processes within farming households management. Climate is a key resource in agricultural production. Climate refers to patterns of precipitation, temperature, wind, humidity and seasons. Regular and predictably patterned seasons, timely rainfall in the right quantities and conducive temperatures facilitate growth of food and cash crops and pastures on which livestock feed. Climate further determines availability of water for both human and livestock consumption. Climate therefore plays a fundamental role in shaping natural ecosystems, human economies and the cultures that depend on it.

Climate has been changing and this change is affecting farming livelihoods. Climate change is defined as a significant and lasting change in the statistical patterns of precipitation, temperature, wind, humidity and seasons over periods ranging from decades to millions of years. Climate change alters ecosystems, impacting on humans and livestock that rely on a given landscape for food crops, pastures and water. Higher temperatures eventually reduce yields of desirable crops while encouraging proliferation of weeds and pests. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines (Nelson, et al., 2009).

The Inter-Governmental Panel on Climate Change (IPCC) forecasts that agricultural production, including access to food, in Africa and other regions would be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in these regions. In some countries, yields from rain-fed agriculture could be reduced by up to 50 percent by 2020. With 95 per cent of agriculture dependent on rainfall, a 20 per cent decrease in length of crop growing season and a 50 percent decrease in yields from rain-fed agriculture, the projected losses in potential for cereal production in Sub-Saharan Africa (SSA) are estimated at about 33 per cent. Local food supplies would be negatively affected by reduced productivity of livestock (feed and fodder availability) and decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued over-fishing (Nelson et al., 2009).

Many actors are promoting key agro-ecological farming technologies and practices that are highly suited to enable farmers to adapt to climate change. These include agro-forestry, crop rotation, intercropping, minimum tillage, soil cover maintenance, residue retention, water conservation, rice systems that reduce methane emissions, improved management of livestock and soil carbon as well as breeding plants and animals adapted for future climate conditions. These practices have been documented to generate higher and more stable crop yields and incomes and enhance resilience to climate change in some countries compared to conventional agricultural production methods. Although these practices are not necessarily new, when used in the context of climatic change, they have been proved to be innovative for farmers, herders and fishermen *(www.fao.org/climatechange/micca/79527, d.a 25/02/2015)*. These technologies and practices are referred to as climate smart agriculture (CSA).

FANRPAN (2013) describes CSA as farming that sustainably increases productivity, incomes and resilience (adaptation); reduces/removes greenhouse gases (mitigation) and improves likelihood of national food security and development goals. FAO (2013) identifies CSA as an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The CSA approach is designed to identify and operationalize sustainable agricultural development within the explicit parameters of climate change (ibid). FAO (2013) adds that CSA contributes to the achievement of sustainable development goals by integrating the three dimensions of sustainable development (economic, social and environmental) to maximize the benefits and minimize the trade-offs by jointly addressing food security and climate challenges.

Wide-scale adoption of CSA practices however, remains a challenge especially amongst smallholder farmers in Africa. There are several barriers that prevent smallholder farmers in Africa from adopting CSA practices and technologies and so far, existing policies and actions to remove these barriers remain inadequate. A good understanding of what these barriers are and how they impinge on adoption of CSA practices is essential. Equally essential are actions that favour the removal of these barriers, while at the same time promote adoption of CSA practices. For farmers to take up a particular CSA practice and for public and private sector individuals to invest in a given CSA practice, the barriers must be seen not to exist.

An identification and critical analysis of the factors that limit adoption of CSA practices and a policy framework will enable policy makers to come up with concrete actions to scale up/out adoption of CSA practices in Africa. This report sought to fill this gap.

1.2 Rationale

According to FAO, there are three levels to consider when making the shift towards CSA: the farm level, the landscape level and the level of the entire food system[1]. Barriers to adoption can also be traced at these three levels. At the farm level, biophysical and management conditions determine the ecological and economic costs and benefits of various CSA practices and technologies, as well as the barriers to their utilization. Bio-physical and management conditions render some CSA practices and technologies unsuitable or make it highly improbable that they will be adopted by smallholder farmers. It is important that farmers are availed a "menu" of CSA relevant practices and technologies that they may select from based on local farming conditions, individual preferences and resource availability. For example, in communities with small farm sizes, limited access to markets and information, and where there is competition for scarce biomass resources between livestock and crops, some CSA technologies and practices may not have much potential. Instead, identification of farm level limiting factors or some farmer typologies that could be addressed by interventions such as land tenure reform, improvements in marketing or information infrastructure may be more significant. In other words, there are certain bio-physical and management specific conditions that should be in place wherever certain forms of CSA are promoted amongst specific smallholder farmers. CSA should therefore be farm/household characteristic specific.

In addition, there are community level barriers that have to be identified before certain CSA practices and technologies are recommended amongst some communities. For example, in some maize farming communities, poor physical infrastructure and remoteness characterised by impassable roads, absence of reliable public transport, long distances to urban centres where inputs are available and associated costs of mineral fertiliser may make it unlikely that these inputs can be a true option for those farmers. Given these constraints, CSA would do well to facilitate greater nitrogen availability by promoting the planting of nitrogen-fixing trees such as *Gliricidia* or to improve the use and establishment of Lablab in the maize farming system. These practices, however, also face barriers related to tenure arrangements, tree rights and dietary preferences (FAO 2014).

Further, there is need to examine the human behavioural, cultural and institutional barriers to adoption of CSA. Smallholder agriculture in Sub-Saharan Africa (SSA) is carried out as a "way of life" within which structures of gender and household organisation which are themselves an interlocking mixture of norms, beliefs and practices. These govern individual household members' roles, rights and entitlements in production, exchange and consumption. Gender and household organisation remain fundamental principles governing the division of labour and determining expectations, obligations, responsibilities and entitlements of males and females within and beyond households. Gender and household organisation in rural households, for example, determine the economic and social roles to be played by men and

[1] (www.fao.org/climatechange/micca/79527, d.a 25/02/2015)

women, boys and girls, of which participation in agricultural production is just one of the many. Gender and household organisation also determine the entitlements and constraints in time, mobility and resources that each experiences in performing this role (Grieco, 1997). Since men and women play different roles, they often face very different cultural, institutional, physical and economic constraints, many of which are rooted in systematic biases and discrimination.

Gender inequality can also hinder adaptation to climate change, including the adoption of climate-smart strategies. For example, the TerrAfrica partnership found that for women farmers, insecure land tenure, limited assets, lack of capital, limited farm inputs, limited mobility and access to information and restricted decision-making power were all common problems and all were major barriers to the adoption of conservation agriculture in SSA. Another study of two ethnic groups in a village in Northern Burkina Faso found that one was successfully adapting to climate change whilst the other was falling deep into poverty. The reason was that the first group's top strategies for livelihoods diversification, which included engaging women in economic activities, were culturally unacceptable to the other group (Gubbels, 2013).

At the landscape level, climate change alters ecosystems, impacting humans and livestock that rely on a given landscape for food and water. There is a strong base of evidence that landscape level CSA techniques are having a major impact on resilience, livelihoods and food security especially in the Sahel. Relevant landscape level CSA practices include soil and water conservation techniques such as "zai planting pits", half-moons, rock or vegetative barriers along the contours, and farmer managed natural regeneration of trees (FMNR) (ibid). Taken together, FMNR, integrated soil fertility management and water harvesting techniques have become part of a growing "re-greening" movement in the Sahel. However, barriers to adoption of landscape level CSA techniques include land tenure, grazing rights, tree rights and rights to participate (ibid).

A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption and disposal of food and food-related items. It also includes the inputs needed and outputs generated at each of these steps. At the level of the entire food system, CSA practices and technologies have focused more on food production and productivity (soil and water resources, crop, livestock and poultry productivity, farm structure, income and management conditions and ecosystem services from agricultural landscapes). The food processing and distribution aspects of the food system such as transportation infrastructure, market infrastructure, agricultural earnings, food prices, food processing and distribution, reliability of delivery, food quality and safety have not been adequately documented. This desk review study identifiesthe barriers to adoption of CSA practices and technologies.

Many national governments across Africa are developing agricultural plans that focus on, or integrate climate change, namely Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Programmes of Action (NAPAs) and National Agricultural Investment Plans. In many cases, these plans are not systematically appraised as business cases. Major uncertainties are inadequately considered when making decisions regarding the bio-physical, management and ecological barriers to adoption of CSA, success of interventions at farm, landscape and entire food system levels, relative benefits, risks and monitoring, reporting, and verification requirements. By adopting the three level framework of shift towards CSA suggested by the FAO, a more rigorous assessment of barriers to adoption will provide strategic recommendations not only for removal of the barriers but also make proposals for CSA public and private sector investment portfolios and incentives that promote adoption of CSA practices and technologies amongst different categories of farmers, farming systems and agro-ecological zones in Africa.

1.3 Objectives of the study

The overall objective of this study is to identify barriers to scaling up/out climate smart agriculture practices and to propose practical actions to remove the barriers and enhance adoption of CSA in Africa. Specific objectives are to:

(i) Examine climate smart agriculture in the context of Africa and assess its potential to address Africa's productivity challenges;

(ii) Identify and analyze the key barriers to smallholder farmer adoption of climate smart agriculture practices in Africa, showing how each factor impinges on the adoption of the practices.

(iii) Identify strategies to remove the barriers and propose practical actions to promote adoption of CSA practices in Africa.

1.4 Study methodology

This is a desk review of factors that constitute important barriers to the adoption of climate smart agriculture in Africa. The study involved an in-depth review and analysis of those factors that have prevented or hindered the adoption of CSA in Africa. The study relied on data and information collected and collated from different secondary sources. These include official and non-official documents including peer reviewed publications and unpublished grey literature. Data and information collected form these sources where collated, analysed and conclusions made.

Section Two

Climate change and climate smart agriculture in Africa

2.0 Introduction

Climate change is already having a significant effect on agriculture, fisheries and forestry in Africa. Some impacts are being felt over time including increase in mean temperatures, changes in precipitation patterns and water availability, sea level rise and salinisation and severe disruptions to important ecosystems[2]. Other climate change impacts present more sudden and extreme weather events such as desperate periods of droughts, extreme heat and/or floods[3].

2.1 Climate change scenarios in different agro-ecological zones of Africa

It is generally accepted that without significant intervention or adaptation by governments, NGO's, donors and most importantly farmers, the changes in climate will lead to more freak weather events and the slowly changing climatic environments will reduce productivity of the agricultural sector. This will in many cases have disastrous impacts, given that 8 out of the 10 countries considered most at risk from climate change in the world are in Africa, according to the Global Adaptation Index[4]. It is therefore not surprising that increasing resilience and safeguarding livelihoods features as one of the top priorities for governments across the continent (CAADP, 2014).

In order to increase the uptake of Climate Smart Agriculture and reach the global target of 25 million smallholder households practicing CSA by 2025 across Africa, it is important that governments, investors, scientists, policy-makers and farmers in general understand more about which possible climate change scenarios are expected for particular areas. It is acknowledged that the global community does not know enough about all the effects of climate change to predict precise impacts, nor in time or local scale[5]. Agro-ecological zones (AEZs) have however provided a useful way to categorise the African continent in order to better understand some of the likely climatic changes to regional environments.

The use of agro-ecological zones as distinguished by the FAO[6] and mapped for Africa by the World Bank in 2008 (Figure 1), has been widely used by researchers and policy-makers alike

[2] FAO Climate Smart Agriculture Source Book, 2013, p5 (http://www.fao.org/docrep/018/i3325e/i3325e.pdf)
[3] http://www.eldis.org/vfile/upload/1/document/1005/JotoAfrika3.pdf
[4] The Countries Likely to Best Survive Climate Change, 2015 (http://www.triplepundit.com/2015/01/countries-likely-best-survive-climate-change/)
[5] FAO Climate Smart Agriculture Source Book, 2013, p16 (http://www.fao.org/docrep/018/i3325e/i3325e.pdf)
[6] http://www.fao.org/nr/land/databasesinformation-systems/aez-agro-ecological-zoning-system/en/

to look at likely impacts of climate change using indicators including yearly crop net value (USD/yr.), irrigation of land, crop types, crops/animals or integration of both.

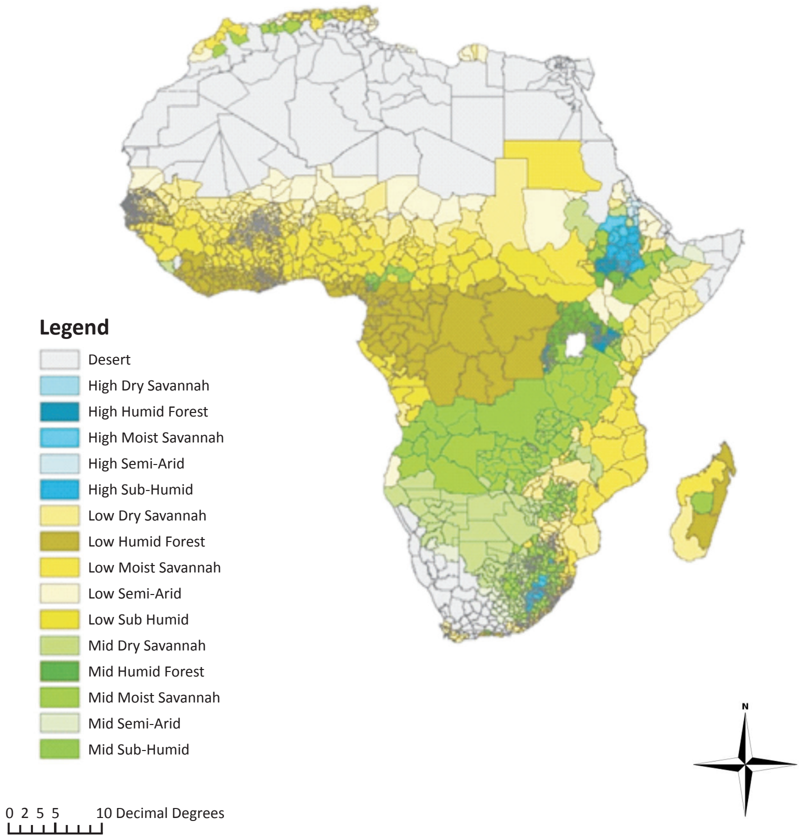

Figure 1: Agro ecological zones of Africa[7]

In order to discuss the likely climate change scenarios within the different agro-ecological zones, the 2008 World Bank study carried out by Pradeep Kurukulasuriya and Robert Mendelsohn[8] has been used as a starting point. This study looks at the shift in AEZ and hence the value of production as farmers chose different crops suitable for the changing climate. Two climate change scenarios[9,10], have been used portraying a moderate and a more severe (CCC) climate impact by the year 2100. These predictions span the range of likely outcomes predicted by the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC 2007). The PCM model predicts + 2oC and marginal gains in precipitation during summer and winter months. The CCC model predicts+ 5oC with drier summers and wetted winters. The change in AEZs not only affects the boundary between

[7] http://siteresources.worldbank.org/INTRES/Images/469231-1178547402235/3754095-1196282687489/Figure1-Agro-Ecological.jpg

[8] How will climate change shift agro-ecological zones and impact African agriculture?PKurukulasuriya, RO Mendelsohn - World Bank Policy Research …, 2008 - papers.ssrn.com

[9] Parallel Climate Model (PCM) (Washington et al.: 2000,Clim. Dyn. 16: pp. 755-774

[10] The Canadian Climate Centre (CCC) Boer et al: 2000, Climate Dynamics (2000) 16:427-450

different climates, it more importantly affects the farming population in terms of the type of farming, the education and training needed to be successful, the investment required to make the change, the value of the new crop and the overall effects on the wider ecological system in the area. Even assuming farmers change crop types according to the changing landscape and climate, the study concludes that across the agro-ecological zones, the productivity in terms of revenue will decline by a significant amount across Africa as shown in Table 1.

Table 2.1 Change in crop net value (USD/year.) in two different climate change scenarios

Agro-ecological zone	Climate change scenario in terms of crop net value (USD/year)		
	Current	Moderate climate change (2oC rise)	Severe climate change – (5oC rise)
All	105,688	-10,000	-35,600
High Dry Savannah	346	+253	+589
High Humid Forest	8,773	+1,630	-3260
High Moist Savannah	1,843	-341	-417
Low Dry Savannah	33,117	+1,660	+11,300
Low Humid Forest	83,055	-35,800	-82,900
Low Moist Savannah	16,097	+2,910	+3,200
Low Semi-Arid	254	+278	+329
Low Sub-Humid	4,862	+3,690	+6,630
Mid Dry Savannah	5,312	-78	-2,600
Mid Humid Forest	4,641	-3,960	-4,660
Mid Moist Savannah	8,716	-1,640	-8,110
High and Mid Sub-Humid	5,923	+2,080	+31,500

Assuming farmers change crop types according to the changing landscape and climate, the conclusion of this study is nevertheless that productivity by 2100, measured as revenue, will decline across the African regions as a whole, totaling around -14% in the moderate scenario and -30% in the more severe scenario (Table 2).

Table 2.2 Change in crop net value in two different climate change scenarios.

AEZ	Moderate change	Severe change
North Africa	-3.7 (-4%)	-5.9(-7%)
West Africa	-9.2(-17%)	-17.4(-32%)
Central Africa	-17.5 (-28%)	-49.2(-79%)
East Africa	-3.1 (-11%)	-3.2(-12%)
Southern Africa	-5.9 (-12%)	-8.4(-17%)
Total	-39.4 (-14%)	-84.0 (-30%)

In essence the 2008 World Bank study shows that there is likely to be movement of the AEZ's, in particular a reduction of lowland humid forest and desert, an increase in lowland sub-humid forest and furthermore a gain in medium sub-humid forest in the more severe climate scenario. Though the size of the shift in AEZ's varies according to the climate change scenario and some reductions are offset by increases elsewhere, the conclusion is that the climate will change and cropland will be lost overall. Adjustments in farming practices will be needed, not only in terms of crop types farmed, in order to optimize profitability or indeed keep food on the table[11]. As the main group of stakeholders, namely the smallholder producers, cannot afford to wait and see what exactly will happen, all the stakeholders in agriculture and food production will be wise to act on best estimates now, being pragmatic and making compromises where needed.

Flooding

Flooding is the most prevalent disaster in North Africa, the second most common in East, South and Central Africa, and the third most common in West Africa (AWDR, 2006).

In North Africa, the 2001 disastrous flood in northern Algeria resulted in about 800 deaths and economic loss of about $400 million. In Mozambique, the 2000 flood (worsened by two cyclones) caused 800 deaths, affected almost 2 million people of which about 1 million needed food, 329,000 people were displaced and agricultural production land was destroyed (AWDR, 2006).

Drought

Between July 2011 and mid-2012, a severe drought affected the entire East Africa region and was said to be "the worst drought in 60 years."

2.2 Climate Smart Agriculture in the context of Africa

Climate-smart agriculture includes proven practical techniques, such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing and improved water management and innovative practices, for instance better weather forecasting, more resilient food crops and risk insurance (Boto *et al*., 2012). Adaptation to CSA can occur in many ways; from the individual field, where a crop is grown, varieties are selected and management decisions such as tillage, fertilization, and pesticide application are made, through the farm level,

[11] (There are three large land changes in the PCM scenario: a reduction of 195 million hectares of lowland humid forest, a reduction of 94 million ha of desert, and an increase of 217 million hectares of lowland sub-humid forest. There are much larger land shifts across AEZs in the CCC scenario. The model predicts a loss of 451 million ha of lowland humid forest, a loss of 335 million ha of desert, a gain of 390 million ha of lowland sub-humid forest, and a gain of 356 million ha of medium elevation sub-humid forest.)
In the PCM scenario, the large decrease of 47 million ha of cropland in lowland humid forest is partially offset by the increases in cropland in high elevation humid forest and all elevation sub-humid forest, lowland moist savannah, and mid elevation dry savannah. The net effect in the PCM scenario is a loss of 27 million hectares (5%) of cropland. With the CCC scenario, the cropland in lowland humid forest is almost completely lost but it is offset by increases in cropland in lowland dry savannah and sub-humid forests at all elevations. The net impact is a gain of 20 million hectares or 4%.)

where managers choose among crops, livestock and other activities and capital investment decisions are made, to the landscape level, where decisions are made about management of water resources, biodiversity, forests and energy (ibid).

CSA shares many of the practices of conservation agriculture (CA). Milder, et al., (2011) define CA as a farming approach that fosters natural ecological processes to increase agricultural yields and sustainability by minimizing soil disturbance, maintaining permanent soil cover, and diversifying crop rotations. Construed more broadly, CA also encompasses natural resource management at the farm, village, and landscape scales to increase synergies between food production and the conservation and use of ecosystem services. As a context-sensitive management strategy, CA can include diverse practices such as livestock and fodder management, improved fallows, agroforestry, watershed management, and community protected areas (ibid).

Under certain conditions, CSA has been found to increase crop yields, enhance carbon content in soils and maintain soil moisture (FAO, 2014). When CSA is used in highland areas, it may further enhance crop production and resilience, even in highly degraded soils, due to the interactive effects of improved plant nutrition and soil moisture. In this way, CSA may be considered consistent with CA goals and is often promoted as a CA practice (ibid). For these reasons, CSA and CA will be used interchangeably in this report.

CSA offers the promise of a locally-adapted, low-external-input agricultural strategy that can be adopted by the poorest and most vulnerable farming communities, as well as by those that can afford varying levels of mechanisation and external inputs. Despite its promise, however, CSA adoption in Africa is low (Milder, et al., 2011). Continent-wide, CSA is used on less than one million hectares, accounting for less than 1% of the total global area under CSA management. Much of this total is attributable to commercial farmers and, outside of a few countries where it has been somewhat widely promoted (e.g., Ghana and Zambia), CSA uptake among small farmers remains very limited (ibid).

In most places where it has been applied, CSA has generated substantial benefits for farmers. Agricultural yields generally increase in the long-term (after 3-7 years), and very often increase in the short-term as well. Profitability typically increases, while labour demands usually decrease and become more flexible and less arduous. These benefits can be particularly important for women and vulnerable groups, such as those afflicted with HIV/AIDS. CSA also helps to improve soil fertility and structure, capture and retain rainwater, and reduce erosion. Through such mechanisms, CSA can increase the ability of smallholder farmers to adapt to climate change by reducing vulnerability to drought and enriching the local natural resource base on which farm productivity depends. For these reasons, CSA should be considered to be a preferred approach to agricultural development for smallholder farmers in most regions of Africa (ibid).

There are several important issues and constraints associated with the practice of CSA in Sub-Saharan Africa (ibid). In many regions, especially those with high population density, low rainfall, or highly degraded land, farmers may find it difficult to allocate crop residues and other biomass to mulching their fields, given competing demands for these materials for fuel, livestock fodder, and other purposes. CSA usually involves a sharp departure from conventional farming practices and may require concerted training efforts and participatory engagement to overcome knowledge constraints and entrenched customs. CSA may also require different farming inputs and implements than conventional agriculture, such as seeds for new cover crops and new hand tools or mechanical attachments. Finally, the benefits and costs of CSA relative to conventional agriculture are likely to be different for men and women. Careful attention to gender dimensions, and to the heterogeneity of household needs and constraints, is important for adapting CSA to maximize benefits at the individual and household levels (ibid).

Despite these potential challenges, CSA for the most part increases synergies among food production, resource conservation, sustainable livelihoods and resilience to climate change and variability. To realize its full potential, however, CSA should be implemented not just as a set of plot-scale agronomic practices, but as a more comprehensive approach that works at multiple scales. Under this approach, the core agronomic practices are supported by a variety of additional activities such as improved seed systems, micro-irrigation, post-harvest storage, composting, tree planting or agro-forestry, market linkages, financial education and services, and establishment of farmers groups and participatory learning models. External inputs, such as fertilizers and herbicides, may also be used; however, since these are seen as synergistic with the agro ecological approach of CSA, smaller quantities are usually recommended. In this way, CSA need not be fundamentally antagonistic to Green Revolution agricultural development strategies, but can be seen as a way of modifying such approaches to make them less input-intensive, more sustainable, and better adapted to climate change and other environmental stressors (ibid).

2.3 Multiple contexts of smallholder agriculture and CSA in Africa

Given the specific nature of CSA, its practice in the context of Africa can be viewed from multiple fronts. For example, smallholder agriculture comprises bio-physical and management components, each with several separate elements. The bio-physical component is comprised of climate, soil, crops, pastures and animals together with certain physical inputs and outputs. The management component is made up of people, values, goals, knowledge, resources, monitoring opportunities and decision making. Smallholder agriculture is therefore a complex combination of all the factors that influence the functioning of the household, the farm and community.

In the context of CSA, FAO (2014) notes that development programmes rarely consider uncertainty and variability in the outcomes of proposed interventions. Yet, uncertainty surrounds all variables typically used to describe agricultural systems, including biophysical factors, such as soil conditions, soil types, harvest dates and climate and socio-economic conditions on small farms, where farmers may be struggling with insecure land tenure, poor access to markets, limited access to information, labour demands and input costs. Other factors include the acceptability of a new product and intra-household distribution of decision-making power. Such factors are often critical in determining the benefits that farmers are likely to receive from adopting new land management practices, including CSA practices and technologies (ibid).

A key challenge in deploying CSA relevant strategies and applying them at a farm or landscape level and out-scaling them to district or regional levels is defining the socio-environmental domain in which particular strategies will perform well. Where and for which farmers will benefits accrue from adopting certain techniques? Where and for which farmers will the same innovations fail to produce positive outcomes? Responding to these questions is fundamental, as development outcomes often depend on system or farm characteristics that vary at small scales. Furthermore, these critical attributes cover not only biophysical factors, but extend into the socio-economic, cultural and political areas (ibid).

Therefore, promotion of CSA innovations outside the social and environmental contexts where they have been tried, tested and evaluated may have a positive effect, no effect, or even unintended negative consequences for the targeted beneficiaries (ibid). For example, evidence for CSA shows that the ability to achieve its goals is highly site-specific, subject to weather and the broader production goals of the household, fertilizer availability and social and labour demands (ibid). The evidence suggests that application of CSA outside its socio-ecological envelope can generate negative outcomes for farmers, communities and the environment. Similar lessons have been found when analyzing other CSA practices, such as fertilizer trees (Ajayi, *et al*., 2011).

Implicitly, the impacts of CSA interventions are highly varied, subject to many biophysical and social influences and dependent on a range of factors. Neglecting uncertainty as an input parameter and failing to consider uncertainty when modelling a structure of proposed responses creates a situation where recommendations or predictions based on averages will almost certainly be wrong when applied to an individual farmer. To present decision makers with useful information on likely outcomes of their decisions, it is essential to consider knowledge gaps and the associated uncertainty (ibid). Generating more detailed information on factors where there is large uncertainty, along with the large effects this uncertainty will have on outcomes, will have a high value for improving decisions on farms, at programmatic and/or policy levels.

2.3.1 Human behavioural and cultural context

Household level

Smallholder agriculture in Sub Saharan African countries is carried out as a way of life, influenced by culturally specific traditional methods and tools of cultivation and modes of organization of the production process. As a way of life, smallholder agriculture is further carried out as an extension of the obligations, roles and responsibilities of different household members in ensuring household nutrition, food security, earning income and enhancing social and economic status within households and communities. In many traditional small holder agricultural communities in Sub Saharan Africa, responsibilities for household nutrition and food security are assigned to females due to their assigned nurturing and caretaker roles within households. Responsibilities for earning income are assigned to males, due to their prescribed role of headship of household (actual or assumed) with obligations for meeting household non-food goods and services requirements and food goods not produced within households.

Plate 1: Road side ponds to recharge groundwater and enhance in situ moisture in soils

Smallholder agriculture in Africa therefore exhibits fairly distinct forms with gender distinguishing and structuring roles, rights and responsibilities of household members in agricultural production, exchange and consumption. Access to land, labour and income are socio-culturally defined. Men, especially heads of household, make the broad management decisions of land allocation, labour organisation, cropping/animal rearing patterns and income expenditure. Men also provide labour for certain crops and at certain stages of the production cycle e.g. ground clearing and breaking. Women's labour obligations in food crop production, household management and child rearing roles are equally socio-culturally determined. Depending on age, gender and whether at school or not, children too have defined roles in smallholder agricultural households. Gender also determines the entitlements and constraints in time, mobility and resources that each experiences in performing this role (Grieco, 1997). African smallholder agriculture is therefore human behavioural and cultural specific, which has implications not only for the response to climate change but also for adoption of CSA.

Farm Level

In smallholder agriculture, it is at the farm level that management decisions such as tillage, use of fertilizers and pesticide application are made. It is also at the farm level that managers choose among crops, livestock and other activities and capital investment decisions are made. It is further at the farm level that crops are grown, animals reared and varieties of both are selected. The decisions at the farm level are influenced by culture (who makes decisions regarding the production process), purpose of production (food security or sale for income), availability of labour, availability of finances, availability of extension services etc., all of which have implications for adopting CSA practices. For example, the availability of farm labour is a major constraint and decision in most smallholder production systems. In many parts of Africa, labour demand tends to be greater than supply, at least seasonally.

Labour is often in short supply due to rural to urban migration (especially by young men), prevalence of HIV/AIDS and other diseases, and under-nutrition and malnutrition. Disease and poor health increase dependency ratios (i.e., the ratio of non-working persons to working persons), which are higher in Sub-Saharan Africa than in any other region of the World (Radeksz, 2010).

On the other hand, sustained and stable food production generated by CA systems can significantly improve the nutritional status of vulnerable households and communities, thus reducing susceptibility to disease and other threats, increasing the availability of productive farm labour and heightening resilience to climate change. These benefits are especially important for households affected by HIV/AIDS, malaria, hunger, war and conflict, migration or adverse weather conditions. For example, in the Laikipia District in Kenya, households affected by HIV/AIDS benefited from reduced labour needs and increased nutrition following CA adoption (Kaumbutho and Kienzle, 2007). Similarly, CA helped affected households in Siaya District, where HIV/AIDS prevalence is over 38% and family members spend significant time caring for the ill. In Southern Sudan, returnees from war found CA to be an attractive option because of its reduced labour requirements (Apina, 2009). CA not only tends to reduce labour in the long-term; it also results in a more even distribution of labour throughout the production cycle. As these examples illustrate, CA can increase labour supply (through better health) while reducing demand, thus creating a labour situation that is much more manageable for rural households and communities.

Evidently, when analyzing the labour implications of CSA, it is more helpful to disaggregate effects by task, season, agro-ecological context, gender and time since adoption than to try to make broad generalizations (Milder, et al., 2011). For instance, in many areas, CSA requires deep-digging to penetrate soil crusts, a task that is very arduous and may increase the initial labour requirement for land preparation. In other areas however, land preparation in CSA requires less labour than in conventional agriculture since whole-field ploughing or tillage is not required. Soil type also affects the direction and magnitude of these differences. Finally, even if total labour requirements are less under CSA, labour requirements for women may be greater, or vice versa (ibid).

Milder, et al. (2011) add that in the long-term, CSA very often reduces the labour required for farming, relative to conventional practice, although this is not universally the case. In the short-term, it is quite common for CSA to require increased labour, especially for weeding and land preparation. Tillage is an efficient way to control weeds, but with reduced tillage, weeding can require substantial initial increases in labour if herbicides are not used. Unexpected labour peaks can also occur at harvest time due to increased yields from CSA.

According to Milder et al. (2011), the following are some recent findings on labour needs in CSA compared to conventional systems in Sub-Saharan Africa. As these results indicate, the labour implications of CSA are highly context-specific depending on the crop, agro ecological context, number of years since adoption, and the nature of the farming system practiced previously. Thus, any efforts to extrapolate such findings to other contexts should proceed cautiously.

- In Tanzania, the time required for land preparation, planting, and weeding was 50-75% lower in CSA than in conventional agriculture (Shetto and Owenya, 2007).

- In Zambia, CSA using planting basins nearly doubled the required weeding effort compared to the conventional method that included ploughing (Baudron, et al., 2007).

- Examining CSA cotton systems in Zambia, Haggblade and Tembo (2003; cited in Baudron, et al., 2007) found that the number of workdays required for weeding nearly doubled (from 45 to 80), while the number of days required for land preparation increased nearly tenfold (from 7 to 66) relative to conventional agriculture.

- Taking into account all land preparation, planting, weeding, and harvesting activities, Boahen, et al (2007) found that CSA required 48 work days per growing season, compared to 83 days required by slash-and-burn agriculture. The greatest labour savings in CSA were those associated with weeding and the collection and burning of slash (ibid).

In addition, most smallholder farmers in Sub Saharan Africa are poor and costs of inputs such as fertilizer, high yield varieties may be prohibitive. Small holder farmers' access to credit in many countries is less than 20%. In addition, some farmers rely mostly on indigenous varieties due to dietary preferences and may take time to appreciate new varieties. In addition, extension services are not common to popularize new varieties and their production methods. In Ghana for example, extension agent to farmer ratio on average is 1 to over 1000 farmers (Opare and Wrigley-Asante, 2008). Thus, farm and farmer characteristics may play significant roles in influencing adoption of CSA practices.

2.3.2 Agro-ecological context: Landscape level

To successfully achieve agriculture that can adapt and mitigate the impact of climate change, it is important to work at the landscape level with an ecosystems approach and combine forestry, fisheries, crops and livestock systems. A landscape-scale perspective to resource management and regeneration maximises synergies between food production, ecosystem conservation, and human livelihoods. It is here that decisions about management of water resources, biodiversity, forests and energy are made. However, some landscapes may consist of different tenure arrangements, ranging from government ownership to communal or individually owned tracts of land and may be subject to different land-use designations. Urgency and incentives for adopting CSA practices may vary within similar landscapes, yet small holder agriculture is dependent on the same landscapes. CSA ideas and practices may conflict with traditional methods of management while resource requirements for promotion and adoption of CSA at this level may be out of reach for small holder farmers, requiring interventions of donors, governments and civil society organisations.

A case in point are pastoralists who occupy very large tracts of Africa, the "Savannah" eco-agricultural zones which are best suited for grazing. This pastoralist area of Sub-Saharan Africa is often overlooked and "hidden" from government attempts to improve food supplies and to increase agricultural yields. It's very inaccessibility is a major obstacle to change too. In addition, pastoralists are often less tractable to conventional approaches, being more mobile and frequently unable to access information, training and formal education. However, supporting the management that these people offer to the land is considered to be one of the most important methods of implementing Climate Smart Agriculture within these environments.[12] A recent report for the FAO on pastoralists highlights gaps in knowledge and lack of systematic research addressing grasslands in many of national and international policies. The roles and values of grasslands are often not visible in international policy-relevant documentation. Future priorities should focus efforts on the environmental and economic values of grasslands, taking into account the effects of social policies on these areas where relevant.[13]

2.3.3 Entire Food System context

A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. It also includes the inputs needed and outputs generated at each of these steps. At the level of the entire food system, CSA practices and technologies have focused more on food production and productivity (soil and water resources, crop, livestock and poultry productivity, farm structure, income and management conditions and ecosystem services from agricultural landscapes). The food processing and distribution aspects of the food system such as transportation infrastructure, market infrastructure, agricultural earnings, food prices, food processing and distribution, reliability of delivery, food quality and safety have not been adequately researched.

Access to markets is essential for smallholder farmers to generate income, strengthen food security and contribute to sustainable livelihoods. Improving access to domestic and regional markets helps them to sell more produce. With the income that they earn, they may be able to invest in their own businesses and increase their production as well as improve the quality of their produce and/or diversify their production, which in itself contributes to building resilience to climate change. Food is also lost due to several market-related factors. First, farmers in Sub Saharan Africa lack or have insufficient access to markets due to high transport costs, resulting from remoteness from markets. Therefore, those who live closer to markets or to better roads are able to engage more with the market and have a higher chance to generate additional income. Besides these physical barriers to access markets, they may also face limitations due to the lack of market information, or business and negotiating experience (FAO, 2005; 2011).

In addition, road infrastructure in rural Sub Saharan Africa is appalling, which heightens transportation costs of food. Transportation costs as well as the price of products increase with poor road infrastructure. A study by Minten and Kyle (1999) in Zaire, (now the present day Democratic Republic of Congo), showed that transportation costs made up one-quarter to one-third of the wholesale price of domestic products due to the poor conditions of rural

[12] FAO report: Global agenda for sustainable livestock, FAO, 2013 http://www.livestockdialogue.org/.

[13] (Restoring value to grasslands)based on assessment of the policy and funding environment, Discussion draft (v.2) 31/08/2014 A. Wilkes (a.wilkes@valuesfd.com) for FAO.

roads. Increasing efficiency means increasing the efficiency of infrastructural systems (FAO, 2009). Furthermore, lack of transport is another challenge that smallholder farmers face. As a result, some smallholder farmers are not able to access markets and thus are not able to generate income that would improve their resilience to climate change in the first place but also facilitate adoption of CSA practices.

Another challenge related to markets is that food is lost because of the lack of markets. At certain times there is an oversupply of some crops, such as the seasonal production of many perishable food crops, which means that there is a temporary oversupply of these crops on the markets. Post-harvest losses in Uganda are estimated at 45%. One of the ways to reduce food losses and to add value to the produce is to process and preserve these foods so that the waste of food is minimized and the loss of income is reduced (FAO 1998; 2011).

2.3.4 Social Differentiation context: Gender and Other Inequalities and Vulnerabilities

No technology or practice (including CSA technologies and practices) is gender neutral. Technologies and practices are introduced into existing landscape of unequal power relations. Without paying attention to existing social and gender relations, there is a risk that the CSA technologies and practices could exacerbate inequalities or fail to capitalise on new opportunities for tackling social inequality. The human impacts of CSA are not always gender-neutral in terms of labour requirements, empowerment or economic benefits and costs. There has not been a large amount of published research that disaggregates labour effects of CSA by gender, but based on available information, CSA can either increase or decrease the total time that women spend on agriculture. For example, CSA reduces or eliminates ploughing, which is traditionally done by men, but may increase labour requirements for women associated with land preparation (e.g., digging of planting basins) and weeding. These increased labour requirements may discourage women from adopting CSA, even when labour requirements decrease in the long-term (Silisi, 2010).

In other contexts, CSA may preferentially benefit women. In Ghana, for instance, the most time-consuming activities in conventional slash-and-burn agriculture are uprooting grass and de-stumping. As these tasks are mostly done by women and children, a transition to CSA was found to increase the time available for other household activities (Boahen, *et al*., 2007). Similarly, in Zambia, a switch to CSA allowed women and children to carry out lighter and more diversified tasks (Baudron, *et, al*., 2007). For female-headed households that have little or no access to plods or ploughing services, CSA may be a more feasible option. Land can be prepared through ripping and seeding can be accomplished with jab planters, which are portable and easy for women to operate (Shetto and Owenya, 2007; Kaumbutho and Kienzle, 2007).

Where CSA reduces the overall time required for farming work, it may allow women to diversify their activities by participating in off-farm income-generating activities (Baudron, *et al*., 2007; FAO, 2010). Because of rural-urban migration and HIV/AIDS, there is a dearth of young males and a high proportion of female-headed households throughout much of Sub Saharan Africa. Lower labour requirements can be a significant advantage for women who are both farmers and caretakers. Reduced work hours, less heavy farm work and lower stress associated with CSA are all valued highly by women (Baudron *et al*., 2007). In Africa, women often play a central role in the decision to adopt CSA, in part because they tend to be more actively involved in small-scale farming than men. In Malawi, the CSA adoption rate for women was found to be 14% higher than the rate for men (Mloza-Banda and Nanthmabwe, 2010), emphasizing women's important role in agricultural innovation. Because of their year-round presence in villages, women may engage more actively than men in farmers' groups or other social structures (e.g., seed saving groups, village savings and loan groups, etc.) that help households adopt CSA and reap its benefits. Investment in CSA may also provide opportunities for increased attention to gender issues in agriculture. For example, CSA practices may encourage more consultation within the family on resource use and greater acceptance of women as leaders (Kaumbutho and Kienzle, 2007).

Section Three

Barriers to adoption of climate smart agriculture practices

3.0 Introduction

Adapting to weather and climate is a characteristic of all human societies, but climate change is presenting new and increasing challenges. Already, smallholder farmers in Africa are using their knowledge, experience and resources to manage climate risks on their own account but these actions are not easily distinguished from a range of other social, demographic and economic factors influencing livelihood decisions and development trajectories (Adger *et, al*., 2003). In spite of the potential of CSA to improve resilience and to enhance agricultural production and rural livelihoods, systematic response to climate change through adoption of CSA practices and technologies is still very limited in Africa for a host of reasons.

This section identifies the barriers or factors that prevent adoption of CSA practices in Africa. These barriers can be classified under two broad categories. The first relates to the physical means or resources required to practice CSA. These can be considered as the hardware barriers and include physical inputs such as land, human resources, equipment, infrastructure and finances. The second, referred to as the non-physical or software barriers, relates to the institutional, cultural, policy and regulatory environments; information, knowledge and skills; technologies and innovations; and governance among others. The hardware and software barriers are summarized in Table 3 and discussed in the sub sections that follow.

Table 3.1 Hardware and Software barriers to adoption of CSA in Africa

Hardware Barriers	Software Barriers
- Limited access to appropriate farm equipments and tools - Inadequate farm inputs and materials, etc.	- Inadequate CSA relevant information, knowledge and skills, etc.

3.1 Physical or hardware barriers to adoption of CSA

Like any other farming or production system, the practice of CSA requires physical inputs (land, labor, capital and materials). When any or all of these inputs is absent or available in limited quantities or volumes, no farmer or company can successfully practice CSA. In most African farm communities, some of these physical inputs are in short supply and therefore constitute a critical barrier to the adoption of CSA. The following sub section identifies and discusses some of the key physical barriers to adoption of CSA.

Limited access to appropriate farm equipment and tools

Limited access to CSA-specific farm equipment and tools is a significant barrier to scaling up CSA in Africa (Milder et al., 2011). CSA may not necessarily require more equipment and tools than conventional agriculture, but some of the equipment and tools are specific and may not always be available. The most significant differences tend to be in equipment and tools used for land preparation and seeding. In areas with silt or clay soils, the soil surface is penetrated only in precisely-targeted lines or pits that will be seeded. Seeds are then deposited into these areas or inserted directly into the ground through the mulch or ground cover layer. Some conventional agriculture equipment and tools can be used for CSA (e.g. certain weeding tools), while others can be modified for CSA (e.g. hand hoes can be made narrower to dig CSA planting basins or rows). For non-mechanized CSA involving simple hand tools the costs are relatively low. Costs increase significantly when using animal or tractor powered implements (IIRR, 2005).

Inadequate farm inputs and materials

Limited access and ability to afford seeds, inorganic fertilizers, pesticides, and herbicides represent a constraint to the practice of CSA in a maximally productive manner (Milder, et al., 2011). However, one of the advantages of CSA is that it can increase yields by fostering biological processes and management practices that enhance soil fertility, pest and weed control where agrochemicals are not available or not affordable. Nitrogen-fixing plants are an integral part of most CSA systems, and can include shrubs, annual herbaceous plants (such as legumes) or trees such as *Faidherbiaalbida*. Intercropping with these species improves yields, soil health, and soil chemical and biological properties while reducing weed and pest problems (Akinnifesiet, al., 2010). Despite these benefits, farmers are unlikely to adopt cover or other crops for soil fertility enhancement alone; the plants must offer some direct benefit, such as human food or animal fodder (Baudron, et al., 2009).

Non-availability and poor access to high-yielding seeds and breeds are also important barriers to the adoption of CSA. Often, CSA requires special seeds for cover crops or intercrops, which are more difficult to obtain if they are species that have not traditionally been grown locally (Milder, et al., 2011). Unless efficient and reliable input supply chains are established, input barriers will continue to be a hindrance to adoption of CSA.

Limited credit and finance

Smallholder farmers aiming to adopt CSA practices often are constrained by inadequate cash to invest in the land, equipment, labor, seeds, breeds and other farm inputs. As noted by Milder, et al. (2011), CSA is generally more profitable in the long-term compared to conventional farming, but achieving these long-term benefits requires initial investment, which is often prohibitively expensive or risky for small farmers to undertake on their own. Vulnerable farmers are especially risk averse due to household food security concerns, and there is little room for error. In addition, while many farmers reap benefits in the first year of practicing CSA, others do not realize increased yields or profitability for 3-7 years (Hobbs, 2007). During this time, farmers sometimes choose to abandon CSA. Thus, long-term adoption is more likely when CSA provides significant benefits in the first or second year (Reij, et al., 2009). Such immediate benefit is more likely when CSA is promoted in conjunction with good agronomic practices, improved seeds, and sometimes inorganic fertilizers (Milder, et al.,2011). The lack of or inadequate financial means to acquire farm inputs constitute an important barrier to smallholder farmer adoption of CSA.

Shortages in labor supply

As earlier mentioned, availability of farm labor is a major constraint influencing decisions in most smallholder production systems. In many parts of Africa, the demand for labor tends to be greater than supply, at least seasonally. Labor is often in short supply due to rural urban migration (especially by young men), prevalence of HIV/AIDS and other diseases, and under-nutrition and malnutrition. Disease and poor health increase dependency ratios (i.e. the ratio of non-working persons to working persons), which are higher in Africa than in any other region of the world (Radeksz, 2010).

In some agro-ecological zones, CSA requires deep-digging to penetrate soil crusts, a task that is very arduous and may increase the initial labor requirements for land preparation (Milder, et al., 2011). In other zones however, land preparation in CSA requires less labor than in conventional agriculture since whole-field ploughing or tillage is not required. Soil type also affects the direction and magnitude of these differences. Even when total labor is less under CSA, labor requirements for women may be greater, or vice versa (ibid).

Milder, et al. (2011) added that in the long-term, CSA very often reduces the labour required for farming, relative to conventional practice, although this is not universally the case. In the short-term, it is quite common for CSA to require increased labor, especially for weeding and land preparation. Tillage is an efficient way to control weeds, but with reduced tillage, weeding can require substantial initial increases in labor if herbicides are not used. Unexpected labor peaks can also occur at harvest time due to increased yields from CSA. However, the labour implications of CSA are highly context-specific depending on the crop, agro-ecological context, number of years since adoption, and the nature of the farming system practiced previously (Milder, et al., 2011).

Zai pits are another conservation technology with labor implications. Zai pits are both a soil moisture conservation measure and a soil fertility improvement technique with high labor requirements. They are particularly applicable in degraded soils. Several environmental and human factors cause irreversible soil and land degradation, leading to reduced soil and water holding capacities. However, in situ moisture conservation technologies such as semi-bunds and zai pits retain rainwater and store it for crop production. Farmers use stone contour bunds to reduce the speed of run-off, allowing infiltration into the zai which collect and concentrate the run-off. Excess run-off is collected into a reservoir for other uses (Ngigi 2009).

Plate 2: use of pits with manure

In West Africa, the zai system, with pits about 10-20 cm diameter and 10-15 cm deep, is a common practice (Bandre and Batta, 2002). Manure is usually incorporated into the pits to improve soil fertility. In each pit, 5-9 plants (sorghum, maize, millet) are grown (Mati, 2007). The holes store rainwater for plant growth, and generally the density is about 10,000-15,000 holes/ha depending on the crop chosen and the spacing between holes. The larger the planting pits and the wider the spacing, the more water can be harvested from the uncultivated micro-catchment areas between the pits. In Niger, zai has been reported to increase biomass yield by 200 percent (Fatondji, 2002). Despite the high initial labor cost, the zai system has been adopted from the Sahel region of West Africa and is now commonly practiced in Eastern and Southern Africa as well (Ngigi, 2009).

High labor needs and costs have been identified by OXFAM (2011) as an important barrier to adoption of zai pits. In West Africa, particularly in Burkina Faso, women do not use adaptation techniques such as zaipits or stone walls since they do not have the necessary physical strength and support. They also do not have access to the appropriate tools (which are reserved for men's plots). As a result, women's plots produce lower yields and are more vulnerable to climate change.

Poor physical and social infrastructure

Physical and social infrastructures are important components in any society or development program. For smallholder farmers to easily adopt CSA and adapt to climate change, there is need for physical infrastructure such as irrigation water supply, water management structures, transport, markets, communication infrastructure as well as storage and processing structures. They also need support from social infrastructure such as farmers' organizations and cooperative societies. Poor and inadequate infrastructure limits adoption and options for adaptation, particularly for smallholder farmers, whose investment decisions depend on good prices for their produce and expected economic returns. Equally important are efficient marketing systems (WDR, 2008) that in turn depend on good road networks, storage and processing facilities to avoid post-harvest losses. Mati (2008) identified infrastructure and availability of markets as the key drivers for success of smallholder development in Kenya. Their absence therefore, constitutes an important barrier to the adoption of CSA practices.

Non-adaptatble egro-ecosystems

Smallholder farmer decisions to adopt CSA can largely be influenced by the agro-ecosystem of the area in which they want to apply CSA. Quite often, the organisms and environment of an agricultural area considered as an ecosystem can influence a farmer's or company's decision to apply CSA. The ecosystem of an area including its people and their activities; geography (climate, weather conditions, topography, ecosystem);economic, socio-cultural and political systems can limit or promote adoption of certain CSA practices. A good example is offered by an FAO research project on Mitigation of Climate Change in Agriculture (MICCA) in East Africa that aims to evaluate the climate smartness of practices, systems and landscapes to support the scaling up of appropriate technologies (FAO, 2014). The pilot project sites were established in October 2011, near Kaptumo, Kenya and Kolero in the United Republic of Tanzania. The two project sites make interesting case studies because of the contrasting farming systems. The Kaptumo site is principally characterized by smallholder dairy farming, widespread throughout Western Kenya, and tea cultivation. In contrast, farmers in the Kolero site manage the landscape using slash-and-burn methods to grow a mix of crops with maize as a staple crop. In addition, there are differences in market orientation (i.e the combination of commercial and subsistence farming versus purely subsistence farming), and potential mitigation opportunities, for example livestock management versus crop intensification and avoiding deforestation. Hence, the primary focus of CSA opportunities in Kaptumo centre on livestock and farm-level management, whereas in Kolero, the focus is on reducing slash-and-burn farming and related agricultural expansion.

The MICCA pilot implementing partners collected and analysed biophysical and socio-economic data to evaluate the ecological and economic costs and benefits of various production practices and systems, as well as the constraints that hinder their utilization.

In Kolero, four options were identified: CA, improved cooking stoves, soil and water conservation, and agroforestry. In Kaptumo, the MICCA pilot project focused on improved dairy feeding (with Napier grass, Rhodes grass, *Desmodium*, sorghum, fodder shrubs, silage and hay making), manure management through composting and biogas, and agroforestry. These data provide the foundation for making recommendations on the significance and appropriateness of CSA innovations for agricultural development in the target regions (ibid).

Despite the promising project findings with regard to smartness of CA, FAO (2014) noted that recommendations need be tempered against constraints in the specific project sites. In Kolero for example, mineral fertilizers can only be purchased in Morogoro, more than 130 km and 5 hours away by dirt road. Poor access and associated costs of the inputs and limited information make it unlikely that mineral fertilizer can be a true option for farmers in the area under current conditions. Given these constraints and the data that suggests that the maize systems are limited in nitrogen, extension programmes would do well to facilitate greater nitrogen availability by promoting the planting of N2-fixing trees such as *Gliricidiaor* to improve the use and establishment of Lablab in the farming system (ibid).

Those practices, however, also face barriers related to tenure arrangements and dietary preferences. Land scarcity is prominent in Kolero. Half of the residents own land as individuals, family or clans. The other half lease or cultivate land under special arrangements from the land owners. Activities related to tree planting and retention are mainly of interest to land owners and have limited uptake (ibid). Thus, potential for expanding agroforestry is limited by land ownership and land tenure systems.

On the other hand, farms in Kaptumo are typically smallholder dairy farms. The type of smallholder farm (e.g. free grazing, semi-zero grazing, and zero grazing) determines activities across the entire farm and has cascading effects on farm structure and management. For example, there is stiff competition for scarce biomass resources between livestock and agricultural crops. Intensification of the system may require the import of feeds and the collection, storage and application of manure. It may also require making silage out of fresh feedstuffs to improve digestibility and milk production. In this situation, the farm is typically a contiguous unit (ibid). Farming in Kolero is characterized by slash-and-burn agriculture, with farmers often cultivating several plots at significant distances from each other. The crop grown is determined by the plot's topographic position and distance from the homestead. Kolero is a landscape in constant transition, as fields shift between cultivation and fallow, forming a complex and changing agricultural mosaic (ibid).

The diversity of the FAO MICCA project highlights the fact that the agro-ecosystem of an area can pose a barrier to adoption of a given CSA practice or promote its adoption. It also identifies locations in which CSA simply does not have much potential and therefore limited adoption and points to the limiting factors in an agro-ecosystem that can stifle adoption if not addressed.

Low volumes of biomass

An agro-ecosystem related barrier with severe implications for CSA than with conventional agriculture is the availability of biomass for mulches or organic fertilizer. In many Sub

Saharan Africa ecosystems, biomass is a critical barrier to adoption of CSA (Milder, et al., 2011). Availability and management of biomass, particularly crop residues and mulches is a critical component of CSA and a major barrier to its adoption in many African agro-ecosystems. Similarly, livestock is an important part of most smallholder farming systems, but the management of grazing livestock severely hinders CSA adoption. Crop residues are often an important source of livestock feed during the dry season, and farmers cannot afford to leave residues in the field while their animals go hungry. In addition, due to communal land tenure that characterizes many smallholder regions of Africa, farmers cannot choose unilaterally to exclude livestock from feeding on biomass available on their lands simply for the sake of implementing CSA. This decision must be made at the community levels, and it is often difficult to change long-standing rules and customs.

Although soil nutrients and soil protection in CSA can often be enhanced by cover crops or intercrops, exogenous organic matter may be needed to provide supplementary fertilizer and soil cover. Non-edible biomass in farm fields and the surrounding field margins, fallows and forests is often in high demand for livestock fodder, firewood, building materials and other uses. CSA places an additional demand on these resources. In areas of low population density or with moderate to high rainfall, biomass is not much of a barrier but becomes a severe barrier in semi-arid regions with high population density.

Limited water availability and natural soil fertility also constrain productivity in native ecosystems, while extraction of biomass as a result of crop harvests, firewood collection, fodder, materials for fencing, roofing and handicrafts and other uses creates situations where annual biomass removal exceeds replenishment. In some areas, termites consume much of the biomass that humans or livestock do not. Additionally, residue is perceived as harbouring pests and diseases. Farm families burn crop residues for this reason or to facilitate land clearing or the hunting of small mammals. Management of biomass, particularly crop residues and mulches, is a critical component of CSA and a major barrier to its adoption (ibid).

Livestock is an important part of most smallholder farming systems, but the management of grazing livestock may severely hinder CSA adoption in sub-Saharan Africa. Crop residues are often an important source of livestock feed during the dry season, and farmers cannot afford to leave residues in the field while their animals go hungry. Where communal land tenure is in place (as it is in many smallholder regions of Sub-Saharan Africa), fields often become available for communal grazing following the harvest. In this instance, farmers cannot choose unilaterally to exclude livestock for the sake of implementing CSA (ibid). This decision must be made at the community level, and it is often difficult to change long-standing laws and customs. Regardless of the tenure system, community level spatial management of land and natural resources can help improve compatibility between CSA and other resource uses, including livestock production. Education and support for such community processes can therefore help support CSA (ibid).

3.2 Non-physical or software barriers to adoption of CSA

Non-physical or software barriers relate to those factors that impinge on the enabling environment needed for the practice of CSA. Successful practice of CSA requires an enabling environment characterized by functional institutions, policies, markets, rules and regulations, and governance structures that favor the generation, dissemination and use of CSA relevant technologies, innovations, information, knowledge and skills. In a community where institutions, policies and markets fail to function; information, technologies and innovations are not generated and disseminated; farmers lack the requisite skills; and cultural practices are not pro-CSA, adoption of CSA becomes a problem. These software barriers are presented in the following sub sections beginning with information, knowledge and skills.

Inadequate CSA-relevant information, knowledge and skills

Information is a powerful tool for enhancing adaptation to climate change and variability (Ngigi, 2009). However, African smallholder farmers either do not have access to appropriate information or are unable to fully utilize existing information. Successful adaptation requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess the options, and the ability to choose and implement the most suitable ones (Lee, 2007). In terms of climate change, this can be demonstrated through acquisition and dissemination of information on weather hazards. Once such information becomes more available and understood, it is possible to analyse, discuss, and develop feasible adaptation measures. Building adaptive capacity requires a strong unifying vision, scientific understanding of the problems, openness to face challenges, pragmatism in developing solutions, community involvement and commitment at the highest political levels (Holmes, 1996). Inadequately trained and skilled personnel can limit a community's or a nation's ability to implement adaptation options (Scheraga and Grambsch, 1998).

Adopting CSA requires substantial changes not only in practices, but also in mindset (Derpsch, 2008). CSA contradicts much of conventional farming knowledge and farming traditions. Many farmers are accustomed to thinking of the plough or the hoe as an essential part of agriculture, and may find it difficult to overcome the idea that ploughing is not required for successful planting. It can be particularly difficult to convince farmers to adopt CSA if they do not experience strong environmental or economic pressures to change. Conventional agricultural practices may also be tightly woven into local culture and ritual, making such practices even more entrenched (Milder, et al., 2011).

While farmers who practice CSA tend to have a positive view of it (Friedrich and Kassam, 2009), lack of experience and evidence-based knowledge hinders adoption. As with agriculture in general, CSA is a knowledge-intensive process that requires substantial planning, intuition and a willingness to experiment and learn. However, the knowledge base for CSA is substantially different from that for conventional agriculture. For instance, the recommended approaches to remedying soil compaction differ considerably between conventional agriculture and CSA, as do methods for seeding, fertilizer application, soil erosion control, residue management and water management (Milder, et al., 2011). When reliable information on CSA is not available from formal support systems (extension agents, NGOs, private sector), neighbours or prior experience, farmers may not be able or willing to adopt CSA fully or optimally from the start, which can lead to disappointing results and subsequent non adoption.

Plate 3: Use of ridgess

Knowledge of CSA remains low across most of Africa, and the approach is rarely taught, even in Universities. Most agricultural advisory service (AAS) personnel have received little formal training on climate-change and CSA. Many of the agricultural training institutions have little capacity in this area as well (Lamboll and Nathaniels, 2011). Although some countries have incorporated CSA into their extension programs, others actively promote conventional farming techniques that are at odds with CSA (Milder, et al., 2011). Even where CSA is taught, this education is often not well integrated with land management systems at the local level. For instance, CSA may be demonstrated in plots at experiment stations, but not in farmers' fields where it is more likely to lead to smallholder adoption (Baudron, et al., 2009). Successful CSA extension models have been demonstrated in several countries, for example in farmer field schools in Uganda (Nyende, et al., 2007) but, with a few exceptions, have not been up-scaled.

Inappropriate technologies and their dissemination

Many of the adaptive strategies for managing climate change[14] directly or indirectly require technologies and innovations. According to IPCC (2001) lack of technology has the potential to seriously impede a community's ability to implement adaptation options by limiting the range of possible responses and interventions. Adaptive strategy and capacity is likely to vary, depending on availability and access to technology at various levels and in all sectors. A community's level of technology and its ability to adapt and modify technologies are important determinants of capacity for change. Awareness and sensitisation to the development and utilization of new technologies are also key to strengthening adaptive capacity (Chapman, et al., 2004).

In particular the choice of appropriate irrigation technology is highly site specific, reflecting geographic, technical and market factors (USDA, 1997). Field characteristics such as field size and shape, field gradient and soil type are perhaps the most important physical considerations in selecting an irrigation system. Other important factors include technology cost; the cost, quality, reliability and flow rate of water supply; crop characteristics such as spacing and height; local climate; market factors such as crop prices, energy costs, and labour supply; producer characteristics (farming traditions, management expertise, risk aversion, tenant/owner status, commitment to farming); and regulatory provisions such as groundwater pumping restrictions, drainage discharge limits, and water transfer provisions. In many cases, technology choices are limited by inadequate financial resources and knowledge. Technology is costly, so farmers must either make money to use it or receive subsidies or incentives to adopt it (ibid).

Technology development and dissemination are other concerns associated with low adoption. Slow adaptation in Africa can be attributed to low technology adoption, and enhanced farmer education would speed up technology dissemination and climate change adaptation (Dinar, et al., 2008). The importance of extension services in technology dissemination, are hampered by farmers' inadequate funds, technical skills and capacities. Any technology seen to disrupt the existing livelihood systems will not be accepted and assimilated easily (Ngigi, 2009). For example, introduction of irrigated agriculture in pastoral communities has always been resisted. However, there are success stories that have been attributed to the way the technology was introduced to the community. Capacity building through demonstration, exchange visits, and incorporation of socio-cultural aspects is key to any technology transfer package. Technology dissemination or project implementation should embrace participatory and cross-sector approaches to ensure effective stakeholder involvement and sustainability (ibid).

Poor governance structure

Governance structure refers to the policy, legal and institutional framework which governs socio-economic development in a country or society (Ngigi, 2009). Poor governance has been cited as a major hindrance to socio-economic development and adaptation to climate change. When the political leadership and management of a country's or community's resources is encumbered by an inefficient bureaucracy, little attention is paid to the urgent need of including climate change adaptation within the national development agenda. The most notable component of a governance structure is the institution, the effectiveness of which depends on a clear policy framework and supporting legislation (ibid).

Institutional constraints limit entitlements and access to resources for communities, thereby increasing vulnerability (Kelly and Adger, 1999). Weak institutional arrangements are not conducive to addressing climate risks and easing the hardship of the people. Inherent institutional deficiencies and weaknesses in managerial capacities to cope with the anticipated natural events affect a country's ability to reduce vulnerability to climate change (Huq, et al., 1999). Appropriate changes in economic and policy conditions are required to make agricultural systems more resilient to changes in climate (Burton, et al.,

[14] Examples include: crop breeding, irrigation, relocation or redesign of field systems, flood management structures and drought proofing.

2001). Inconsistent and unstable agricultural policies have increased the vulnerability of the food production and security in Sub Saharan Africa. Thus, political and institutional inefficiencies have resulted in resource inequities in Sub Saharan Africa (Magadza, 2000), thereby compromising the resilience of poor and vulnerable smallholder farmers.

Ngigi (2009) observed that established institutions in developed countries not only facilitate management of current climate-related risks but also provide an institutional capacity to help deal with the risks associated with climate change. For example, evolving strategies in the water resource sector based on demand management tools are capable of providing a basis for adaptive response strategies to climate change. Further, IPCC (2001) noted that the accumulation of numerous small changes in the present range of water resource management practices and procedures increases the flexibility for adaptation to current climate uncertainty and serves as a precursor to future possible responses within an ill-defined, changing climatic regime.

Sector-based governance structures can be blamed for poor water resources and low adaptation capacity to climate change in Sub-Saharan Africa (Ngigi, 2009). For instance, despite the importance of groundwater, its beneficial use is often constrained by weak social and institutional capacity, and poor legal and policy frameworks. This difficulty may become significant in internationally-shared surface and ground water resources because of contrasting capacities and institutional frameworks on each side of a border. Attention must therefore be paid to critical elements such as setting up an adequate framework for cooperation, capacity building, participation, raising awareness, investment and appropriate technology (ibid).

Generally, the African continent has inadequate adaptive strategies to optimize the use of water resources. Where they do exist, there is inadequate governance structure and political will to implement them. South Africa, Zimbabwe and a few countries have begun to develop strategies to optimize use of water resources, for example, water pricing and demand management tools to cope with water scarcity (Inocencio, et al, 2003). Although construction of storage reservoirs are practical options, demand management which reduces consumption per unit of product output has proved increasingly to be a water-saving strategy that can allow communities to enter a drought cycle with adequate supplies (IPCC 2001). But there are many other instances where appropriate adaptation strategies are not being effectively implemented. For example, most crop watering technologies by smallholder farmers in SSA are labour intensive and inefficient. Industrial and household water recycling and re-use have not been adopted as a water saving strategy in most countries (Hamdy, et al 2003). These need to be adopted.

To enhance adaptation and integrated water-resource management, both restrictive and incentive measures should be employed. Supportive governance structures are therefore appropriate means of providing extension services, credit facilities, equity in allocation of resources, information dissemination and a good policy environment. IPCC (2001) noted that it is frequently argued that adaptive capacity is enhanced when social institutions and arrangements governing the allocation of power and access to resources assure that access is equitably distributed. The extent to which nations or communities are entitled to draw on resources greatly influences their adaptive capacity (Kelly and Adger, 1999). Scheraga and Grambsch (1998) noted that "differentiation in demographic variables such as age, gender, ethnicity, educational attainment and health enhances the ability of community or a nation to cope with risk".

In West Africa, there is no clear policy and institutional framework on adaptation to climate change, especially by smallholder farmers. However, there are intentions of policy scattered around various domains such as land and water resources management, which could have some relevance to adaptation to climate change (Ngigi, 2009). Therefore, unless the existing gaps in related governance issues are addressed, it will be difficult to initiate CSA interventions in countries with such unclear and conflicting ministerial mandates. Moreover, different sectoral policies should be harmonized to reflect how each related sector plans to address climate change. There have been some positive moves to address these incoherencies. For example, a recent shift in the location of irrigation from ministry of agriculture to ministry of water in many countries is a positive institutional reform milestone. Ironically on-farm water management has remained in ministry of agriculture, hence de-linking the software component of AWM (Ngigi, 2009).

Unfavorable land tenure systems

Land tenure is the system of rights and institutions that govern access to and use of land (Adams, 2001). Milder, et al., (2011) observed that land tenure arrangements that are ambiguous, informal, or overlapping can inhibit individual investment in sustainable soil and water management (including CSA). Customary tenure systems are typical in the small farmer-dominated rural areas of most African nations (ECA, 2003). These tenure systems often combine individual and communal rights within a framework defined by written or unwritten customs and governed by decision-making authorities at the family, clan, chief, or village level. Given that customary tenure systems vary widely, it is helpful to identify some of the characteristics of these systems that can pose barriers to adoption of CSA (Milder, et al., 2011). These include:

- **Duration and security of individual rights to land:** CSA represents a long-term investment in the fertility and sustainability of a farm plot. Clear, long-term individual (or household) rights to the land can encourage such long-term investment, while the absence of such rights may discourage it (Boahen, et al., 2007; FAO, 2010).

- **Governance and decision-making for communal plots:** Since farming communities tend to be risk averse, where land is communally owned, there may be social pressure to use well-tested conventional practices as opposed to practices that are unfamiliar or perceived to be risky, such as CSA (Milder, et al., 2011).

- **Conceptions of ownership based on active use:** In many customary tenure systems, use rights are claimed and retained through individuals' active use of land. Planting of annual crops demonstrates active use, whereas long fallows or natural regeneration, even if done deliberately, may be perceived as the discontinuation of active use. The perceived lack of active use may make the plot subject to claims by other potential users. Perennial systems including agroforestry may help individuals retain use rights without needing to plant annual crops each season (ibid).

Investment in improved Agricultural Water Management (AWM) is affected by access to water, which is also linked to land tenure (IWMI, 2009). AWM refers to interventions aimed at increasing water availability and utilization for productive use for crops, fishery and livestock in both rain-fed and irrigated agriculture. It includes land and water management, soil and water conservation, rainwater harvesting and management, irrigation and drainage, aquaculture and agricultural watershed management (Ngigi, 2009). According to Ngigi, secure land tenure is a prerequisite to investments in climate change adaptations related to water and land management. In the Mubuku irrigation scheme in Uganda, Ngigi reported that a development partner withdrew due to an insecure land tenure system. The land tenure issue is more pronounced in large scale public irrigation schemes, managed by many smallholder farmers in Africa. The Mwea irrigation scheme in Kenya and Office du Niger irrigation scheme in Mali demonstrate how ensuring farmers' land tenure has increased rice production, improved water management and initiated scheme expansion, which would otherwise not have been possible with central government control of the entire production system.

However, there are many large irrigation schemes managed by smallholder farmers where the story is different; farmers have no incentive to invest in improved water management, land husbandry or high-yielding varieties because they are "tenants" of government or its agencies. Tenant farmers have limited rights to the land and hence inadequate power to influence decisions and policies affecting their plight. Insecure land tenure has also fuelled conflicts among pastoralists and irrigators, especially where irrigation encroaches on pastoral land. This has been the case in many large public irrigation projects like Bura and the proposed Tana Delta in Kenya, and has led to project failure (ibid).

Culture limitations

Culture can present opportunities as well as barriers to adopting CSA practices. Nielsen and Reenberg (2010) in a study of the Rimaiibe and Fulbe ethnic groups in the village of Biidi in Northern Burkina Faso reported that the Rimaiibe were successfully embracing livelihood diversification to adapt to climate change but the same adaptive approach was not considered viable by Fulbe. The Rimaiiibe's chief adaptive strategies (labour migration, working for development projects, growing gardens and including women in economic activity) contravene Fulbe's sense of personal integrity and freedom. Fulbe identity is bound to the annual practice of transhumance (they herd livestock across Burkina Faso's central plateau between December and June). Among Fulbe men, transhumance is considered to be a proof of independence and self-worth. Transhumance continues to be pursued even though the plateau is becoming increasingly cultivated and inhabited, which makes the practice more and more difficult. Fulbe view sedentary crop cultivation less favourably than itinerant livestock rearing. In addition, hiring oneself out for work or migrating for labour is not considered an option.

Until post-colonial legislation in the 1980s afforded Rimaiibe rights and land, they were effectively slaves to the Fulbe. This history makes Fulbe even more reluctant to be associated with activities that are proving successful for Rimaiibe. Highly prizing their self-sufficiency, Fulbe tend to live scattered in the bush at some distance from the village. The Rimaiibe live closer together in the village. When development practitioners hire workers for day labour, they do so in the village centre, which is easily accessible to Rimaiibe, but not Fulbe. Finally, strongly defined gender roles make Fulbe men reluctant to include women in income-generating activities. These cultural factors that have created barriers to adapting to changing conditions have led to a sharp rise in Fulbe poverty and food insecurity (ibid).

These insights offer an idea of how local cultural institutions may complicate the uptake of climate change initiatives that have succeeded in other contexts. Understanding the local culture is useful when formulating CSA adoption, up and out scaling strategies. In this Burkina Faso case study, it became evident that development practitioners had to meet the Fulbe in the bush and the Rimaiibe in the village. They could not assume that Fulbe would come to the village centre when in need of paid work. Dialogue about cultural practices and beliefs along with an exchange about securing physical and economic well-being is also advisable (ibid).

Gender inequalities

In many parts of Africa gender remains a significant barrier to the adoption of CSA by women; stemming largely from customary gender roles. For instance, women in Africa often have less access than men to resources such as land, inputs, credit, education, and extension services, all of which may be important to support transitions to CSA (Silisi, 2010). In addition, gender biases in institutions often reproduce assumptions that it is men who are the farmers. As a result, new agricultural technologies, including the replacement of plant types and animal breeds with new varieties intended for higher drought or heat tolerance are rarely available to women farmers.

Land ownership systems also present more entrenched barriers to female-led CSA adoption. Land tenure systems in parts of Kenya, for example, require women who want to adopt CSA to obtain permission from male relatives (Kaumbutho and Kienzle, 2007). In Lesotho, women who make improvements to land that they farm but are not allowed to own, risk losing their fields to male relatives (Silisi, 2010). In parts of Ghana, women have access to less agricultural land than men, and may thus be less willing or able to experiment with new farming techniques whose outcomes are unknown (Boahen, et al., 2007). In addition, gender biases in institutions often reproduce assumptions that it is men who are the farmers (Gurung, et al., 2006). As a result, new agricultural technologies, including the replacement of plant types and animal breeds with new varieties intended for higher drought or heat tolerance are rarely available to women farmers (Lambrou and Piana, 2006).

Limited peoples' rights to participate

In 2010, CARE launched the Adaptation Learning Programme for Africa (ALP) whose overarching goal is to increase the capacity of vulnerable households in Sub-Saharan Africa to adapt to climate variability and change (Manyire, 2012). Gender equality and diversity constitute a particular focus for ALP. Activities are targeted to ensure that benefits reach people in the most vulnerable socio-economic groups. These are identified through participatory analysis. The programme promotes the rights and responsibilities of men and women in adaptation activities. It empowers people in the most vulnerable socio-economic groups to take concrete action and to raise their voice in local, national and international planning and policy-making processes on adaptation.

As part of the ALP programming, CARE Kenya conducted a study in Garissa County, North Eastern Province, Kenya, amongst two Somali livelihood systems: the agro-pastoralist system comprising of riverine farming, sedentary livestock and rain-fed crops in semi-arid lands in Fafi district and the pastoralist system involving nomadic livestock herding and trade in arid lands in Lagdera district. The purpose was to conduct a gender analysis at community levels that built on previous analysis to deepen the CARE Kenya country team's and communities' understanding of gender rights, roles and relations and how they interact with the adaptive capacities of households and communities (Manyire, 2012).

The study revealed that females had limited participation rights because they were excluded in Somali-based society. The strict and rigid sexual/gendered division of labour in livestock and crop production whereby nearly all the activities in the two livelihoods' production cycles were described as masculine in Somali/Islamic/nomadic pastoral norms and practices were bound to constrain adaptation measures unless the measures became gender conscious. For example, earning household income, major decision making within households, rights to the management and control of household major assets including land, crops, livestock, improved/resilient seeds and their benefits and income accruing were construed as men's responsibility. Hence, women play a peripheral role in community based adaptation (CBA). This upholds an Islamic belief that one male is equal to two females, an ideological justification for the subordination of women and denying them rights to livelihoods, unless dependent on men as wives, mothers and/or daughters. The elderly and/or widowed females who were not dependent on men could lay more claim to productive assets than their younger and/or married counterparts (ibid).

In addition to gender, age and socio-economic status played important roles in determining access to public spaces and services and meaningful participation in public decision-making. For instance, younger men do not participate in public decision making when older men are present, according to Somali cultural norms. Alternately, very old women can participate in public decision making. The Somali expression *inanlugtete la daye* meaning that a woman who can no longer lift her legs during sexual intercourse (one who is no longer sexually active) has the same rights as men, hence can participate in public decision making. Persons with disabilities (PWDs) can also not participate in public decision making because disability is regarded as a curse in Somali culture. Poor persons regardless of gender do not participate in public decision making; their opinions and views are not even heard, unlike those of the rich who participate most in public decision making within communities. Thus, axis of exclusion especially gender, age, physical ability and socio-economic status were key determinants of participation in CBA (ibid).

Limitations on women's voice, movement and participation in public and household decision making has deeply institutionalized women's social exclusion and unfavourable inclusion in Somali society. Coupled with male resistance and women's own internalized subordination, the limitations further curtail women's aspirations for themselves, including aspirations to participate in CBA. The social exclusions and unfavourable inclusions, acting singularly or in various combinations, have ultimately evolved local sub-cultures amongst women which limit and undermine their capacities to have aspirations for themselves other than those prescribed by Islamic and Somali culture - wifehood and motherhood. These are likely to pose barriers to adopting CSA practices and technologies.

Limited grazing rights

In many customary tenure systems, farmers possess individual rights to manage their fields during the planting season, but these fields revert to communal spaces available for livestock grazing during the dry season (Milder, et al., 2011). Such arrangements pose a major challenge to farmers who wish to conserve crop residues or other biomass for CSA. In principle, it is possible to modify systems of communal grazing rights to allow farmers to exclude livestock and retain biomass in their fields, but doing so tends to be politically challenging and there are few documented instances of this occurring.

In a Rangeland Rehabilitation and Management Programme planned to graze 6,000 cattle and 3,000 sheep and goats in the dry season reserve in Laikipia, Kenya, FAO (2013) noted that there are a number of social factors that presented barriers to adoption. A major challenge arose when community members resisted their leaders' decision to adopt the plan throughout their lands. The goal-setting and future visioning component of the programme was then introduced to the leadership. This component requires an articulation of the quality of life desired: what needs to be produced or created (tangible and intangible) to attain that quality of life and what future resource base is needed to meet these needs. The value of this exercise is two-fold; it allows deep self-reflection and it guides and encourages more socially, ecologically and economically-sound decisions (ibid).

One startling result of applying the visioning tool was that the leadership realized that current management structures were producing opposite results from those they desired. It was decided that a reorganization of the community management structure was necessary. This process resulted in the formation of "village" management forums written into their constitution, whereby primary responsibility for all management actions was placed in the hands of a Village Forum, with the overall community management bodies playing a supporting rather than directing role as they had previously tended to do. This resulted in a shift from a top-down to a bottom-up structure and a pooling of the previously separate management committees under the single village management body for different issues such as water, education and grazing. It all came about when the community identified that the separation of activities which were in fact closely connected, resulted in activities that were undermining each other. These changes allowed members to adopt improved practices while the programme continued to focus on facilitating building capacity of the new Village Forums, with each village forming its own "future-vision" to guide social, economic and environmentally-related decisions. Challenges constantly arise, but discussions using the visioning tool usually facilitate arriving at appropriate solutions; a process which communities have found empowering. As many elders commented: "we never thought we had a choice about our future".

Limited tree rights

In communities where not all are land owners and some lease or cultivate land under special arrangements with the land owners, activities related to tree planting and retention are mainly of interest to land owners and have limited uptake (FAO, 2014). Non-land owners usually have no rights to trees. Agro-forestry in many regions is still constrained by local customs, institutions and national policies (FAO, 2010b). Some national policies forbid harvesting of tree products even when the trees were planted by smallholders.

Other barriers to adoption of agro forestry relate to tree ownership. Evidence from the Sinsibere project that was implemented in the outskirts of Mali's capital Bamako revealed that individual ownership can contribute to success in adoption of agro-forestry (Mali-Folkecenter Nyetaa, 2008). In the beginning of the project, one of the activities was planting trees. Most of the trees had not been successfully maintained. The lesson learned was not to plant trees on common land but instead commit individual people or families to plant them on their own land. It was also found that there was more success when seedlings were sold, even at a very small price, than when given out freely (Mali-Folkecenter Nyetaa, 2008).

Section Four

Strategies and actions to enhance adoption of CSA in Africa

4.1 Introduction

The previous section has provided a battery of factors that limit adoption of CSA practices in Africa. This explains why according to Milder, et al., (2011), CSA is practiced on less than one million hectares in Africa; accounting for less than 1% of the total global area under CSA management. Much of this is attributable to commercial farmers. If the barriers are left unaddressed, African smallholder farmers will not benefit from the productivity gains of CSA. This section presents strategies and practical actions for removing the identified barriers while simultaneously promoting adoption of CSA.

4.2 Actions to enhance adoption of CSA

Creating awareness about climate change and what CSA can do

Many African smallholder farmers and farm communities experience low crop and animal yields but are unaware that this is partly as a result of climate change. Many also are not aware of what to do to remedy the situation. The current climate change discourse is very much promoted by international NGOs and some civil society organizations with little contribution from local farmers and communities. An indigenous (African) critical consciousness to climate change is still lacking. It is therefore important that this consciousness is cultivated and raised at all levels in order to change perceptions of climate change for Africa to take responsibility for addressing the challenges it presents. Most of the challenges can be addressed through adoption of CSA. Whereas resource constraints may limit the practice of CSA, increased consciousness about climate change can enable farmers and farm communities to generate the resources to enable them practice CSA.

Facilitating access to finance and credit

Several approaches have been used to overcome the dual financial constraints of the initial investment required for CSA and the potential for negative returns for several years after adoption (ibid). Both of these constraints can be overcome by providing low-cost inputs, extending credit to farmers through direct loans or establishment of community financing operations, and educating farmers about the benefits of CSA and ways to improve its profitability. Other rural finance mechanisms can also help farmers overcome the short-term investment hurdle to adopt CSA practices that are more profitable and sustainable in the longer term.

Commercial banks and microfinance institutions are generally absent in most rural areas of Africa. However, a variety of community savings and lending models have been implemented successfully throughout the continent. These include rotating savings and credit associations and village savings and loans groups. The latter has been adopted widely within the projects of the charity "CARE" in Africa. These groups pool household resources and agricultural profits to create a structured collective mechanism for savings, short-term lending and investment in household economic activity. With or without these various forms of financial support, farmers can hedge financial risks by adopting CSA piecemeal or on a fraction of their farm. Doing so reduces short-term expenditures and allows the farmer to guard against the possibility that yields will drop before they rise. Piecemeal adoption is a logical strategy at the household level, but makes it difficult to institutionalise CSA rapidly over large areas (ibid).

Mainstreaming gender equality in CSA initiatives

There are multiple compelling reasons to incorporate gender equality in climate-smart agriculture initiatives and where necessary, provide incentives and participatory education and training oriented specifically to women. This is not a simple task. There are many challenges, especially if the goal is not just to be gender-sensitive or equitable in climate-smart agriculture interventions, but to actually work to transform gender relations as part of the process (Chaudhury, et al., 2012). Climate-smart agricultural initiatives are much more likely to achieve their desired outcomes if they encourage women to take ownership and implement changes at the farm level, ensure that women have the resources to do so by reforming institutional arrangements (structure), and work with men to ensure that they value the contributions and ideas of women in regard to this role (relations) (ibid).

Case studies show that involving different members of the community, men, women and young people, is critical to ensuring effective joint learning on locally relevant climate smart practices (ibid). Co-learning strategies help both to create new spaces and to provide the additional support that may be needed to encourage dialogue at household and community levels about the roles of women and others in supporting agricultural innovation. Such strategies can be employed to help reduce structural inequalities around resource access and to encourage male support for change. Visits and participation in multi-stakeholder dialogues are key to adaptation and mitigation due to the rapid pace of change and the global nature of the challenge (ibid).

Plate 4: Community Mobilization to construct ridges, micro-pits, pits with manure and water dams

Facilitating information and knowledge use in climate change and CSA

There is a lot of data and information on climate change and CSA on-line and there is substantial internet connectivity in Africa. For example, data and information on seasonal weather events that can disrupt existing agricultural practices can easily be accessed and utilized by farmers and farm communities wanting to adopt CSA. For this to happen however, their capacities need to be strengthened to enable them collect, interpret, internalize and understand how climate can influence their farm practices.

Farmers and farm communities need to appreciate the need to adopt CSA practices. This appreciation in turn necessitates availability of information explaining the need for CSA adoption. Provision of information and knowledge about the short- and long-term benefits of CSA practices, for example CSA's ability to increase yields by fostering biological processes and management practices that enhance soil fertility, pest and weed control regardless of use of agrochemicals, is a good strategy.

Plate 5: use of micro pits for water retention

Information about the properties of Nitrogen-fixing plants that include shrubs, annual herbaceous plants (such as legumes) or trees such as *Faidherbiaalbida* is also important.

Strengthening the capacity of farmers and local communities to understand climate change as well as appreciate the benefits of CSA requires an initial critical mass of personnel capable of instilling into farmers information and knowledge about climate change. People need to be trained to collect, collate and disseminate information about weather hazards and to facilitate analysis, discussion and development of feasible adaptation measures. Nonetheless, building overall adaptive capacity requires a strong, unifying vision, scientific understanding of challenges, openness, pragmatism in developing solutions, community involvement and commitment at the highest political levels.

Changing peoples' mind sets on climate change and CSA

Most, if not all smallholder farmers in Africa are already used to and conversant with conventional farming methods using traditional hand tools. Departing from these methods is sometimes a challenge, especially if the new methods are not highly mechanized. Climate smart agriculture differs from conventional farming knowledge and farming traditions in terms of methods for soil preparation, seeding, fertilizer application, soil erosion control, residue and water management. In most cases, ploughing is not required for successful planting under CSA. *Adopting CSA therefore requires substantial changes not only from conventional farming knowledge and practices, but also mind sets*.

Whereas conventional farming knowledge and practices are informally passed on from generation to generation through socialization processes within households and communities, CSA is too recent to be wholly assimilated into farming cultures of African small holder farmers. *It is important that peoples' mind sets on climate change and CSA are changed through development and teaching of CSA curricula in agricultural institutions* at all levels. In service courses should also be developed for practicing extension staff. Further, CSA extension models should be demonstrated in farmer field schools and demonstration farms, for instance. In order to facilitate quicker and wider adoption at community levels, farmers willing to experiment with CSA practices should be fully supported by donors and/ or governments so that the skeptics can observe first-hand the practice and benefits of CSA.

Enhancing the capacity of farmers to adopt and use new technologies and innovations

The ability of farmers to apply new technologies and innovations is an important determinant of CSA adoption. Farmers need to be sensitized on existing technologies and innovations to appreciate and adopt them. Sensitisation and awareness creation on existing new technologies and innovations is key to promoting adoption and strengthening adaptive capacity. However, new technologies and innovations are costly and sometimes complicated to apply; so farmers must either have the resources, receive subsidies or are given incentives to adopt them. Availability of markets, especially for value added products can spur investment in new CSA technologies and innovations and therefore promote adoption.

Slow adaptation to climate change in Africa is partly attributed to low technology adoption. Most agrarian communities are used to traditional technologies that were over generations inculcated into them informally within household and community settings. Any technology not inculcated through early socialization or seen to disrupt the existing livelihood systems will not be accepted and assimilated easily. Therefore, building the capacity of farmers through demonstration, exchange visits and incorporation of socio-cultural aspects is an essential component of any technology transfer package. Technology dissemination should embrace participatory and cross-sector approaches to ensure effective smallholder involvement and sustainability. Overall, enhanced farmer education can speed up technology dissemination and adoption of CSA.

Making farm equipment, inputs and materials affordable to farmers

Lack of or inadequate financial resources has been identified as a limiting factor to the acquisition of farm inputs and materials needed for successful practice of CSA. This barrier can be removed by making farm inputs and materials affordable to farmers in various ways including:

- Facilitating access to finance:Compared to conventional farming, some CSA practices require substantial investments that need to be made upfront. Such investments are generally more profitable in the long-term (3-7 years) than in the short-run. Yet, majority of smallholder farmers in Africa are financially constrained to undertake such initial investments on their own. Considering that adoption is more likely when benefits are anticipated in the short-run, smallholder farmers need financial assistance to enable them practice CSA. Such assistance can be in the form of provision of credit at low interest rates.
- Provision of subsidies that are eventually phased out gradually over time.

- Removal of or reduction in import duties on farm equipment, tools and other inputs.
- Reducing transport costs, particularly for farmers located in enclaved rural areas.
- Educating farmers about the benefits of CSA and ways to improve its profitability.
- Linking farmers to community micro-credit finance institutions

These actions will enable farmers to procure improved seeds and breeds, inorganic fertilizers, pesticides and herbicides, and other inputs such as labor and machinery that allow them to effectively practice CSA.

Increasing volumes of biomass

As pointed out in the previous section, availability and management of biomass, particularly crop residues and mulches is a critical component of CSA and a major barrier to its adoption in many African agro-ecosystems. The practice of CSA is problematic in farming communities with limited volumes of biomass or in communities with high demand for available biomass for livestock and other uses. Regardless of the tenure system, landscape level management of land and natural resources can help improve compatibility between CSA and other resource uses, including livestock production. Education and support for such community processes can promote adoption of CSA. Key in education campaigns is demonstration to communities of levels of rangeland degradation and erosion and depletion of soil organic carbon, a key indicator of regeneration potential and healthy plant growth. Demonstrations to smallholder farmers of how their poor farming and livestock management practices lead to reduced volumes of biomass is equally important.

Planned grazing can enhance adoption of CSA because it lets the grasslands to rest. The aim is to never leave the land bare, not to deplete the roots and also leave some grass behind for wild life. But this requires community buy-in and participation. Forage assessment is one method of planned grazing, whereby estimates are made of the amount of grass available for a specified number of livestock for a number of days. The livestock only eats a certain amount and is then moved elsewhere. Another approach is getting livestock owners to agree to bunch their livestock in bigger herds so that the hoof action breaks up the hardpan so that rain water can penetrate, instead of running off. Another approach is concentrating kraals in heavily overgrazed areas to enrich the soil with dung and urine manure.

Also, in farm communities where there is stiff competition for scarce biomass resources between livestock and agricultural crops, adopting CSA requires importation of additional biomass and the collection, storage and application of manure. It may also require making silage out of fresh feeds to improve digestibility and milk production, in addition to reduced livestock density, improved dairy feeding, manure management through composting and biogas, and agroforestry. In sloppy, predominantly crop farming areas, barriers to adoption of CSA could be removed through reducing slash-and-burn farming, improving soil and water conservation and agroforestry. To meet medium to long-term biomass needs and also increase the availability of nitrogen needed by CSA, it is important to plant nitrogen-fixing trees such as *Gliricidia*.

Improving physical and social infrastructure

Inadequate physical and social infrastructure restrict availability of adaptation options, especially for smallholder farmers, whose investment decisions depend on good prices for their produce, efficient marketing systems, good road networks and ready market and storage facilities to avoid post-harvest losses. Removal of physical barriers such as poor roads, communication and energy infrastructure is often beyond the ability of smallholder farmers. These require heavy investments that can come from the government or community. While governments and communities can use multi-sectoral approaches to provide these types of infrastructure, communities can come together to construct market and storage facilities that smallholder farmers can use for a fee. The private sector can also be encouraged to provide these facilities at a fee. From a social perspective, farmers can organize themselves into farmers' organizations and cooperatives to provide these facilities for their members. Farmers belonging to these social groups are more apt to adopt CSA knowing that they no longer face the barriers posed by poor infrastructure.

Promoting peoples' rights to participate

Adaptive capacities of households and communities depend on communities' understanding of individuals' rights, roles and relations with others. Often, gender, age, marital and reproductive status are axes of social and economic differentiation that determine rights to participate in decision making at household and community levels. Axes of social and economic differentiation further determine access to public spaces and services and meaningful participation in public decision-making, all of which are prerequisites for household and community based adoption of CSA. Unfortunately, social and economic

Plate 6: trenches to control run off water

differentiation and the resulting exclusion and/or unfavourable inclusion are regarded in many communities as “natural’ or “givens”, hence are rarely questioned even by the excluded and/or unfavourably included.

It is therefore important that communities’ consciousness to socio-economic differentiation and the resultant exclusion and/or unfavourable inclusion of segments of society is awakened amongst not only different gender, age, marital and reproductive status groupings but also amongst formal and informal institutions within societies. Plans and programmes for consciousness awakening should simultaneously be linked to livelihoods and current challenges of poverty, food insecurity and agricultural development within the context of changing climate and adoption of CSA. They should further be tailored to allow participants to question, contemplate and discuss in a gradually unfolding, none threatening (to deeply held beliefs) manner, thereby adopting a willingness to unlearn the learned behavioural and attitudinal norms and practices that promote exclusion and/or unfavourable inclusion within households and communities. Such approaches would enhance participation rights including rights to participate in fora that promote adoption of CSA.

Strengthening institutions, policies and governance structures

Outside donor initiatives, little attention is paid to the urgent need of including climate change adaptation within the national development agenda in most African countries. Even before the climate change discourse, inconsistent and unstable agricultural policies had increased the vulnerability of food production and security in Africa. Political and institutional inefficiencies have resulted in resource inequities thereby compromising the resilience of poor and vulnerable smallholder farmers. Appropriate changes in institutional and policy conditions are required to make agricultural systems more resilient to changes in climate. However, the effectiveness of the appropriate conditions will depend on clear policy frameworks and supporting legislation not only to facilitate management of current climate-related risks but also provide an institutional capacity for adoption of CSA. The institutional capacity should be holistic, encompassing critical elements including adequate frameworks for donor/government/community/farmer cooperation, climate change awareness raising, CSA adoption capacity building, equitable participation regardless of age, gender, ethnicity, educational attainment and health status, public, private, community and individual investments and appropriate technology.

In addition, there should be institutional frameworks for provision of extension services, credit facilities, ensuring equity in allocation of resources and information dissemination. The institutional frameworks should further scrutinize and put in place mechanisms for addressing the informal social institutions and arrangements that promote differentiation and subsequently, inequitable allocation of power and access to resources, that present barriers to enhancing adaptive capacity.

Most African countries lack clear policy and institutional frameworks on adaptation to climate change, especially by smallholder farmers. However, there are intentions of policy scattered around various sectors such as lands, forests and water resources management, which could have some relevance to adaption of CSA. It is important that the different sectoral policies are harmonized through a governance structure to reflect how each related sector plans to promote adaption of CSA.

Ensuring secure tenure of land

CSA represents a long-term investment in the fertility and sustainability of a farm. Hence, secure land tenure is a key prerequisite for investments in climate change adaptations related to land and water management. This is because clear, long-term individual (or household) rights to land can encourage such long-term investments, while the absence of such rights may discourage it. Issuance of authoritative individual, household or community level certificates of land ownership by recognized central and/or local government authorities would secure farmers' rights to land. In communities where certificates of land ownership may not be feasible, for example where land is communally owned and rights to the land are defined by written or unwritten customs and governed by decision-making authorities at the extended family, clan, chief, or village levels, adoption of perennial systems including agroforestry may help individuals and/or households establish, claim and exercise tenure rights that can encourage them to adopt CSA.

Protecting grazing and tree rights

In many customary tenure systems, there are a number of social factors that present barriers to adoption. Whereas farmers possess individual rights to manage their fields during the planting season, these fields revert to communal spaces available for livestock grazing during the dry season. Such arrangements pose a major challenge to farmers who wish to conserve crop residues or other biomass for CSA. Community members could also resist their leaders' decision to adopt CSA practices over their lands. To overcome these barriers, it is important to enable communities to set goals for a climate smart future that simultaneously meets social and economic goals. This requires an articulation of the quality of life desired: what needs to be produced or created (tangible and intangible) to attain that quality of life and what future resource base is needed to meet these needs. The value of this exercise is two-fold: it allows deep self-reflection and it guides and encourages more socially, ecologically and economically-sound decision making.

Agro-forestry in many regions in Africa is still constrained by local customs, institutions and national policies some of which forbid harvesting of trees and tree products even when the trees were planted by smallholder farmers. Guaranteeing rights to trees especially by those who planted them can contribute to success in adoption of CSA. For the owners would be entitled to the multiple uses of trees and tree products, hence would have incentives to plant them.

Promoting CSA success stories and opportunities

For a farmer, life is filled with calculated and uncalculated risks. Therefore they will be naturally risk averse in their adoption of new ideas. For CSA to be successfully adopted by farmers, it will be important to remember this concept in the presentation of opportunities. Particular emphasis should go on the successes of CSA and opportunities for farmers to limit risk. There are many successes of CSA both from research and in the field. Identifying and promoting successes will engage adoption. There is opportunity for farming groups to gain financial support from Carbon Credit Systems particularly as a result of carbon sequestration in soils (Harvey, G., 2008).

Promotion must develop a demand driven approach. It will dispel any concept that CSA is incompatible with production and profit. In fact the reverse is the truth. This concept will engage the key stakeholders. Smallholders have a hunger for digestible practical and applicable information that is not being met. Traditional practices in Africa are variable. Many cultures contain a strong element of respect for local traditions, respect for the communal structure and respect for elders. This provides an opportunity for many beyond the primary contact. Thus engaging the well-respected members of communities can provide a strong way to engage the local farmers in CSA.

Farmers view their activities on the ground involving land, animals, climate, financial availability, storage, marketing and the needs of the family. They view the smallholding and its potential in an overall context. The smallholders want total productivity and production in various forms not one output.[15] Large developed farms for example use spread sheets and computer programmes to optimise on the whole farm production. Smaller farmers do this empirically in their heads balancing the wide range of options. This can be very successful although bias can enter from other factors.[16] Into this mix CSA can successfully be introduced to improve their situation.

Raising the profile of CSA

Some purists of CSA consider that it should not adopt modern promotional techniques. However, a strong set of promotional strategies across Africa at every level with all relevant stakeholders is vital to its adoption into ground level use. There are several methods with which this can be carried out, using a variety of dissemination sources to attract interest and educate stakeholders of the importance and benefits of CSA. Some potential options have been laid out below. However, it will be necessary with the use of detailed analysis to determine the best methods although well recommended and established methods should not be overlooked. It is important to be aware at all times of the target groups to which the promotional material is being aimed, whether it be farmers, national governments, research institutions, donors or NGO's. Material should always be tailored to suit the target group and their objectives and needs.

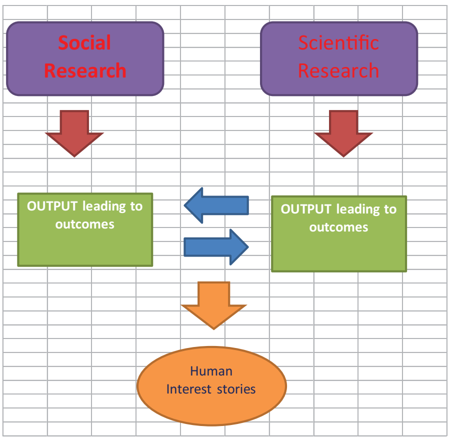

Chart 1: Routes to providing good media stories

[15] With the exceptions of special situations related to subsistence production.

[16] For example an older parent may put pressure to "do what your father and I did"

Developing a clear image of CSA

Branding involves creating a unique name and image for a product, or in this case a set of concepts, in the users' or consumers' minds. This has been done successfully in Africa with the Brand of "Fair Trade". It has encouraged consumers, particularly in the developed and richer countries, to consider the ethical implications of the use of their spending power. Branding should: deliver the message clearly, confirm the credibility, connect with your target prospects emotionally, motivate the buyer or user and harden loyalty to the concept.

Consistent, strategic branding leads to a strong brand equity, which means added value, interest and potential for investment. Branding can be achieved in a number of ways (some of which have been expanded below) such as developing a tagline or strapline:

- Competitions
- Creating a logo
- Brand messaging or a "voice"
- Design templates and create brand standards for your marketing materials
- Internet and social media presence
- Multimedia – videos, audios, podcasts, radio shows
- Incorporation of personalities – for example celebrities or national/regional/local figures of importance.

Creating a memorable sub-head or strap line

The recognition of the name Climate Smart Agriculture is high in specialist professional circles. The name is clear and well established. However in the broader agricultural community, others in the groups which are the target of this report do not have such good name recognition for CSA. The name could be improved by adding a sub-heading or strap line. This is commonly carried out in commercial products as part of the promotion and marketing. The subheading is a popular description of the "product". It can be and often is longer than the title. It may be necessary to write a memorable, catchy, meaningful and concise statement that captures the essence of your brand, as discussed above.

Encouraging competitions and awards

One technique is to set up an annual competition for the separate groups: Governments, research organisations and staff, and farming individuals or communities. Such competitions are known to increase interest and raise the profile of any occasion. There are many examples of prestigious awards, from the Nobel prizes to Farmer of the Year awards in many developed countries such as the UK. Such local competitions are widely covered in national news media and can help raise the prestige of the stakeholder communities. A competition prize can be an award or trophy for excellence and a small financial prize is often an added attraction. Individuals and organisations alike relish the prestige such an award can bring (BBC Radio 4, 2015).

In the case of FARA, it would be necessary to set up regional awards based on the four groups of agricultural research stakeholders. There would need to be an awareness of local cultural aspects and international rivalries. However as a concept to raise the profile and effectiveness of climate smart agriculture, competitions offer a fresh approach worthy of consideration.The respect that the different groups engender is different for each sector.

- For farmers, neighbours' respect is based on success in growing crops or managing livestock so that there is sufficient food and income to support children's' education, family health and potentially to build enough reserves for cultural expectations such as provision of a dowry or marriage gift.
- For research staff, the respect of peers is often based on the ability to publish papers in respected international scientific journals, on promotion status within an organisation and freedom and finances to travel to international conferences.
- For elected governments, respect is based on their ability to fulfil the expectations of the electorates, international donor organisations and their international peers.

In each case a group competition based on CSA offers a fresh approach to increasing respect among peers which could yield significant status rewards for each group separately. One example of the use of this technique is the "SEEDS Awards" (UNO, 2015) for sustainable development which is supported by several large donor organisations including the UN and EU. It is quite possible that FARA could integrate within the existing organisation 's structures and make farming and agricultural research categories in the existing award structure. That would require negotiation with the SEEDS programme and supporting donors.

Establishing a Web Portal

There is a substantial opportunity for governments, research organisations, NGOs and farmer representatives to share information on a dedicated Web Portal about CSA. The Africainteract, Africa-adapt and RAILS (Regional Agricultural Information and Learning System) websites contain some of the characteristics but need a much wider remit and audience. A portal is more than a simple website; it is much more flexible and allows users to choose what information to see or to submit.

It is extremely important that such a web portal is not too complicated (as many portals are). Simplicity of language and a limit to the number of links is vital to ensure it is easy to use. Too many web portals are cumbersome and difficult to navigate, sending users down ever more annoying branching links and clicks. Good design not only of presentation but also of content is vital. Apart from providing instant clarity on tried and tested methods, the database should also help identify avenues which are in their infancy and work as a research programme for African nations, NGOs and donors etc. to bridge the gaps with farmers. This would enable more substantiated information (leaflets, funding opportunities, cooperative initiatives etc.) to be disseminated to farmers which are suitable to their needs, smallholding size and climatic conditions.

A web-portal could have the following characteristics:

- Be user specific with different portals dependent on user needs, i.e. whether the focus is on farm level, policy development or data for research etc.
- Be searchable so partners can focus on for example, specific topics such as crops/ livestock types, agro-ecological zones
- It could signpost funding and investment opportunities, such as directions for microfinance, government support schemes, bank credit etc. at local level and

international donor and NGO support at national and intra-national level.

- Sign-posting training courses, workshops and other educational events.
- Act as a dating site for partners who share the same climate, economic, social conditions and are interested in collaborating on research development or even investment for key infrastructure or similar programs of work.
- Contain applications such as being signed up to a notification when relevant or updated information is added on a specific topic
- Interactive tools for planning a garden/farm that highlights methods, tools/labour, investment and funding opportunities.
- Links to case studies, Inter-continental forum meetings, publications and web-based portals to discuss lessons learnt for thematic actions including on the theme of Drought Risk Management (Jotoafrika, 2015), Fisheries (Africanfisheries.org, 2015) and so on.

Although it might be pertinent for the web-portal to be 'owned' by one body, such as the African Union/NEPAD, mainly for maintenance and editing rights, the obligation to provide information should be carried by all relevant partners including African nations, the AU, the UN, NGO's and independent research bodies. Funding for research could be dependent on additional deliverables in support of the portal, i.e. practical guidelines, findings in bullet-points and simple to understand language, key benefits and challenges, timescales etc.

Preparing an interactive programme for CSA

Modern technology is becoming an increasing part of many people's lives. With the introduction of smart phone games, social media and the internet are quite literally at people's fingertips. The younger generation is very engaged in screen based presentations and activities. There are currently available productions and games that allow a group to compete to grow crops/rear livestock in an online simulated scenario. These are popular and well used by many mainly young people in western society. They can help to market and explain the benefits and methods involved in CSA in a way which is appealing and understandable to the modern generation.

To date, there has not been one produced and contextualised to Africa [generically] or one which incorporates the concepts and benefits of CSA. Such a production could easily be made. It's nature would allow the users to gain knowledge in a positive and interactive way. The media capabilities in Africa are ever increasing.[17] Africa is creating online mobile phone applications and has the capability to develop such programmes.

Using Communication Trees

Using farmer-to-farmer "communications trees" can improve communication and overcome distrust of taking risks. Farmers are quite rightly naturally risk averse and require good evidence that changing the habits of a lifetime are worth the risks. Creating a community with easy access to CSA information will encourage the uptake of CSA at ground level. It will allow the opportunity for dissemination of material as well as the opportunity to ask questions, share experiences. Abilene Resanumami, a Malagasy rice farmer speaks on an IFAD video (IFAD, 2015):

[17] The complex programmes that organise the booking for major international airlines were developed in Africa

"Well, you know in the countryside it is difficult to do it the first time. People are reluctant to get involved until they see the results from someone else's field. Once they see that it's worth it, you don't need to try and convince them anymore."

Using successful farmers to spread a message of better techniques can be successful either directly face-to-face or with the use of promotional videos. Face-to-face is a relatively slow but extremely successful technique, needing several harvests for the knowledge to disseminate over a wider area. However, governments need to take the ideas and techniques on board. Farmers themselves cannot be expected to actively promote or send farmer advocates to other areas without support in form of labour or finance, for the home farms or villages from which the farmer advocates travel.

Focusing actions at the landscape level

To successfully achieve agriculture that can adapt and mitigate the impact of climate change, it is critically important to work at the landscape level with an ecosystems approach and combine forestry, fisheries, crops and livestock systems. Landscape-scale perspective to resource management and regeneration does maximize synergies between food production, ecosystem conservation, and human livelihoods. For it is here that decisions about management of water resources, biodiversity, forests and energy are made. However, same landscapes may comprise of different tenure arrangements, ranging from government to communal to individually owned tracts of land and may be subject to different land-use designations. Urgency and incentives for adopting CSA practices may vary within similar landscapes yet smallholder agriculture is dependent on the same landscapes. CSA ideas and practices may conflict with traditional methods of management while resource requirements for promotion and adoption of CSA at this level may be out of reach for small holder farmers, requiring interventions of donors, governments and civil society organisations

Simplifying key messages and recommendations on CSA

The list of options provided by scientists and investigators is extensive and contains broad contextual examples and explanations. Many of the working stakeholders will have limited or no time and capacity for reading and absorbing information. Simplifying the recommendations of CSA and presenting them in a form which is accessible to all stakeholders will have a big impact in its absorption and adoption into future activities. As part of this, preparing a series of posters that could be displayed in national ministries of agriculture, schools and communal farmer locations should be considered. In addition this base will be suitable for modern "push technology"[18] approaches.

Providing easily accessible weather forecasting systems for Agriculture

Many countries have used a variety of communication media for forecasts such as radio, television and mobile phones. These have had a significant reach. A promising channel is that of mobile phones. Making easy-to-understand weather and precipitation forecasts available to small-holders via mobile phone will require governments to put in place the infrastructure to allow technology solutions to develop. The role of governments can be either direct investment as nation states with other potential partners or in directing

[18] This involves promoting to key stakeholders.

international development organisations to help with this. One example of success in this is improving weather information systems in Rwanda. The European Space Agency has assisted in the development of a mobile phone app which can assist in forecasting rainfall and potential diseases in coffee crops.

> *"Using a 'big data architecture' researched by ESA to handle datasets so large that they are difficult to process using traditional applications, Weather Safe developed that initial concept into a set of products for different players in the coffee chain: farmers, processors, exporters and government agricultural departments." (Phys. org, 2014)*

In addition, the Rwandan government made ICT technology a priority area, (de la Croix Tabaro, J. and Ngabonziza, D. , 2015).

> *"The newly elected Secretary General of International Telecommunication Unions (ITU), Zhao Houlin, says Rwanda is hotspot for ICT businesses. Houlin, who is in Rwanda for a three-day visit, inspected K-lab- an open space for IT entrepreneurs in Rwanda's capital Kigali. Rwanda's ICT infrastructure creates an environment for lucrative business in the sector.*
>
> *"ICT solutions require infrastructure background and you are on good track," he said. "You now need to start small and medium enterprises in ICT domain to make use the available opportunities," he added. (PR Newswire, 2015).*

Adopting policies aimed at pastoralists who frequently cross national borders

Pastoralists are often an underappreciated spectrum of the agricultural industry. They are often left out of policy decisions. Government policy towards pastoralists can offer many solutions to the problems they face through making changes in national policy frameworks.

> *"For many smallholders and pastoralists, livestock are essential for income and nutrition. The contribution of livestock to food security and health can be strengthened through investments and targeted policies that sustainably increase the productivity of smallholder and pastoral production systems and access to, or development of markets" (FAO, 2013).*

Water rights are an important component of agriculture. Livestock need drinking water. Families need household water. Thus access to good clean fresh water is important. Further the water in rivers passes on to lakes and eventually the sea. Conventional agriculture is increasingly carrying out activities that contaminate water and damage each of these uses of water. The contamination can go into ground water when it remains a local issue or into river courses when it may cross national boundaries. The two main issues are:

- Fertiliser run-off contamination. This is caused with the application of fertilisers at inappropriate times in the crop life and application flowed by heavy rainfall.
- Soil run-off contamination when forms of conventional tillage – digging or ploughing of various forms – are followed by heavy rain before crop establishment.

Both these can be reduced by appropriate usage of CSA methodology which can be incorporated into policy frameworks. News that for example Egypt, Sudan and Ethiopia signed an agreement on water rights of the Nile on 23rd March 2015 is positive news for the CSA developments (Al Jazeera, 2015).

Promoting cross-border cooperation

This is a barrier which can only be overcome by international co-operation between neighbouring countries. There are some examples where different states have made treaties which allow movement of native inhabitants to move and trade freely across borders. One such treaty is that of the Australia - Papua New Guinea Treaty. Despite the presence of national boundaries, the two countries have signed an international agreement that allows free movement of local people across the Torres Straits (which separates the two countries) without the need to produce identity documents and with no customs fees. The document explicitly outlines co-operation with native inhabitants over traditional hunting and fishing rights (UN, 2002). Where such treaties exist, CSA can find space within.

Section Five
Recommendations

It is evident that there are major hindrances limiting the adoption of CSA practices in Africa especially among the smallholder farmers. For CSA to have the desired impact on the adaptation of global agricultural systems in Africa, it must be applied across geographical, social, economic and political contexts. However, for farming communities within each of these contexts the obstacles that impede or complicate CSA adoption are different. Therefore, local-level assessments are necessary to first verify the suitability of target practices and subsequently to determine how their widespread adoption might best be facilitated. The following are recommended to policy makers if CSA practices should take off in earnest in Africa:

1. Creating awareness and raising the profile of CSA by promoting CSA success stories and opportunities to smallholder farmers.

Adoption rates hinge on subjective variables such as farmers' awareness of new practices, personal willingness to adopt them, and overall concern for the problem the practice aims to address. Farmers may be generally willing to adopt new practices, but perceive a specific practice to be inadequate, unnecessary, or difficult to incorporate into existing management systems. Most, if not all smallholder farmers in Africa are already used to and conversant withconventional farming methods using traditional hand tools. Departing from thesemethods is sometimes a challenge, especially if the new methods are highlymechanized. Showing empirical evidence of the benefits derived from practicing CSA to farmers will encourage some to venture into the practice. Some will still be hesitate because they are not risk takers. Some of the successful CSA practices that have created results include:

I. 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) has shown Increase of sorghum and millet yields of up to 1t/hectare (100%) over unimproved land in Burkina Faso

II. Fertilizer micro dosing has shown Crop yield increases of up to 100% and increase in farmers' incomes in the Sahel regions

III. Association of Guierasenegalensis trees with crops has shown 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.

Governments and non-state actors should consciously promote these success stories for other farmers to adopt.

2. **Mainstreaming CSA in national development programmes and institutionalizing gender equality in CSA initiatives.**

Most of the national development programmes do not emphasize climate smart agriculture as mechanism to address climate change issues. It is however essential to mainstream CSA in national developmentprogrammes if we want it to be widely adopted

3. **Facilitating access to finance and credit to smallholder farming opting to adopt CSA.**

Smallholder farmers avoid taking risk in their farming operations. There should be enough financial guarantees to secure their family livelihoods. Without these various forms of financial support, farmers can hedge financial risks by adopting CSA piecemeal or on a fraction of their farm. Doing so reduces short-term expenditures and allows the farmer to guard against the possibility that yields will drop before they rise. Piecemeal adoption is a logical strategy at the household level, but makes it difficult to institutionalize CSA rapidly over large areas.

4. **Creating enabling environment by strengthening institutions, policies and governance structures that enhance CSA adoption is critical.**

Institutional investment in agricultural communities (infrastructure, extension services, health care) will affect farmers' ability to absorb risk and, in turn, adopt new practices. Legal and political frameworks also influence adoption rates. An example was sighted as policy on informal seed fairs and genetic resources can affect farmers' ability to save seed of locally tolerant varieties or access improved varieties through exchange with other farmers. Thus, technological, social, economic, and institutional factors all play a role in whether target CSA practices can or will be adopted, both within farming communities and on the national and regional scales.

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About FARA

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

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

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

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

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

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

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

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

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

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

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

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

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