Evidence of Impact: Climate-Smart Agriculture in Africa

Working Paper No. 86

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Summary

The vulnerability of Africa's agriculture to climate change is complex. It is shaped by biophysical, economic, socio-cultural, geographical, ecological, institutional, technological and governance processes that interact in intricate ways, and can together reduce farmers' adaptive capacity. Women farmers with few resources are particularly vulnerable. This working paper highlights the array of adaptation strategies that exist across Africa's diverse farming systems and climatic conditions. These strategies can provide the impetus for transforming Africa's agriculture. The case studies show how farmers are already adapting to climate change, what kinds of investment and how much is needed, and what local and national leadership is necessary to increase adoption and scale up. Successful case studies are broadly defined as those that identify, test and implement climate-smart agriculture (CSA) practices and institutions, counter the impacts of climate change and offer the highest returns on investments. These CSA practices offer the best chance of food security and many other benefits for the people of Africa in the long term.

Key messages:

- Africa's agriculture must undergo a significant transformation to meet the challenges of food security, poverty, climate change and environmental degradation. Government and private sector investment in climate-smart agriculture can help achieve this transformation.
- To build smallholder farmers' resilience to climate change there needs to be greater adoption of integrated CSA technologies. These should contribute to food security and reduce poverty, greenhouse gas emissions and environmental degradation.
- CSA practices need to provide incentives and market opportunities that will transform subsistence agriculture into profit-led enterprises. Practices should support the development of enterprises that offer diverse and sustainable sources of income to help cushion families through difficult periods, such as drought and floods.
- Multi stakeholder collaboration is needed to share information and address similar agricultural problems at different levels (national and regional).
- Climate change adaptation strategies must be appropriate to women's capacities and needs.
- Governments must support and enable the growing private sector by providing appropriate markets, infrastructure and policies. Responsive national and regional markets should be promoted that provide access to credit and finance schemes to enable farmers to invest in new and emerging climate-smart technologies.
- An enabling institutional and policy environment is needed that supports agricultural research and education oriented to farmers' needs, as well as the diversification of farming systems.

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Introduction

Africa's climate is changing

Climate change is emerging as one of the major threats to development in Africa. Agriculture is particularly at risk. Without suitable adaptation strategies for each farming system, the challenge of climate change cannot be effectively tackled.

Many sources project changes to Africa's climate, at regional and continental levels. By 2050 in East Africa, Hulme et al (2001) and the Intergovernmental Panel on Climate Change (IPCC 2001) both project warmer temperatures, 5–20% more rainfall between December and February, and 5–10% less rainfall from June to August under a warming scenario. This warmer climate will affect fishing in coastal and aquaculture systems, and will cause a decline in crop production, particularly in maize (Roessig et al 2004, Fick et al 2005, Funk et al 2005).

In North Africa annual rainfall is likely to decrease by 4–27% leading to droughts and increased salinity (Radhouane 2013, IPCC 2014, Barkhordarian et al 2013). The IPCC estimates that crop and fodder growing periods in western and southern Africa may shorten by an average of 20% by 2050, causing a 40% decline in cereal yields and a reduction in cereal biomass for livestock (FAO2010a, Lobell et al 2011, Thornton et al2009a, 2009b and 2009c).Western, Central and southern Africa may experience a decline in mean annual rainfall of 4%, 5% and 5% respectively (IPCC 2007, IPCC 2014, Hoerling et al 2006).

Only in East Africa is rainfall anticipated to increase. The other four regions are likely to experience drought conditions that will be more frequent, more intense and longer lasting. As a result, the area of arid and semi-arid land is likely to increase by 5–8% by 2080 (Elrafy 2009, IPCC 2007).

Africa's food security is at risk

These scenarios present a major challenge to agriculture in Africa, severely compromising food security and livelihoods for millions of people. The prevailing farming systems are extremely sensitive to drought. Across the continent, by 2020 crop yields are projected to decline by as much as 50%; by 2100 crop net revenues may fall by up to 90% (Jones and Thornton 2008). Livestock keepers in agropastoral and pastoral systems, and smallholders' mixed crop–livestock systems are likely to be affected by a drop in the availability of animal feed and water, as well as the changing severity and distribution of pests and diseases affecting both livestock and fodder (Thornton et al 2007, Jones and Thornton 2008).

Africa's annual population growth rate is estimated at 2.4% (Haub and Kaneda 2013) and food demands are expected to increase with rising populations. The region's population is on course to more than double from its current 0.9 billion by 2050 and quadruple to 3.9 billion people by 2100. Yet, according to the UN Food and Agriculture Organization (FAO), more than a quarter of sub-Saharan Africa's people are currently undernourished, and the region already imports roughly 20% of its staple calories. The region would need to

increase crop production by 260% by 2050 in order to feed its projected population. To provide food and energy for nearly 2 billion people, Africa's agriculture must be transformed.

Africa needs to engage its farmers and communities, and mobilize its technological and financial resources to adapt to climate change. The economic and social costs of failing to adapt will be extremely high. Droughts are already increasing in frequency and intensity across most of Africa, disrupting agricultural production (IPCC 2007, Huntingford et al 2005). Action is needed now.

The promise of climate-smart agriculture

Climate-smart agriculture (CSA) offers an opportunity for Africa to identify, research, develop, and scale up technologies and practices that respond to the changing climate and meet increasing food demands.

CSA is defined by FAO (2010b) as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and poverty reduction". It can provide the impetus for Africa's agricultural transformation through its capacity for risk management and also promote targeted investments in agricultural production, technologies and infrastructure.

CSA practices and technologies include a variety of integrated options that build on the diversity Africa's farming systems and fisheries. These integrated options include agro-ecological approaches, sustainable natural resource management, and ecosystem management that are central to climate change adaptation. CSA can also involve action around agricultural value chains, food waste and consumption.

About this working paper

Managing Africa's agriculture in a changing climate to ensure food security requires a concerted effort to reframe current CSA practices, and ensure they are appropriate for an African context. We need to bring together current knowledge and approaches to equip African farmers and governments with knowledge, skills and attitudes to respond to and shape changes in agricultural and farming systems.

This working paper shares the CSA practices and technologies that exist across Africa and have already created positive impacts for farmers. These practices have potential to be scaled-up across the continent, and yet are largely unknown outside their areas of implementation.

This working paper is aimed at government planners, extension and local government staff, development professionals, and practitioners in development agencies, as well as civil society organizations working to support African agriculture.

Selection criteria for CSA case studies

Many innovative CSA practices exist in Africa with the capacity to increase productivity and build resilience. Yet they remain largely unknown at continental or even regional levels. This working paper describes case studies of CSA practices in agriculture that achieve the 'triple win' of adaptation, mitigation and food

security. These case studies support future interventions in agriculture: they identify the challenges faced, factors critical for success and opportunities for scaling-up.

Other authors have previously documented successful CSA case studies that have potential for transforming low yielding agricultural production into more productive and sustainable systems. Cooper et al (2013) identified 16 successful agricultural adaptation and mitigation cases, half of which were from Africa, and presented evidence of large-scale initiatives that can achieve the triple win scenario. For example, FAO (2013) highlighted 6CSA success stories from Africa, which also integrated biodiversity and gender aspects. Finally, Winter bottom et al (2013) identified several land and water management practices that increased crop yields, as well as supplies of valuable goods such as firewood and fodder, income and employment opportunities, and resilience to climate change.

The case studies described in this working paper add to the previous studies. They describe a range of different situations, including small and large-scale interventions, and practices implemented in one country or many. The current case studies go further to explore the investments needed in terms of partnerships (national and international, development and donor agencies); financial and human resources; gender integration; market access; and low-carbon agricultural development options. In addition, the current study showcases agricultural innovations that target adaptation and yet show great potential in terms of climate mitigation and vice versa.

The case studies are drawn from African agriculture, livestock and forestry sectors. They include both rain-fed and irrigated agriculture, and examples of on-farm practices only, and practices at the landscape level. The interventions are led and implemented by governments, NGOs, communities, multilateral organizations, and national and international research organizations. The CSA innovations were all 'climate change related' because they demonstrate one or a combination of the following: (i) adaptation technologies and practices in agriculture, (ii) knowledge and capacity, (iii) policy processes, (iv) financing adaptation and (v) co-benefits.

A number of criteria were used to select case studies. CSA practices were selected which:

- have been implemented at regional or national levels, covering tens of thousands of farmers or hectares;
- demonstrate impacts at household, national or regional levels (such as increased productivity and income, reduced land degradation or opportunities for value addition);
- enhance farmers' capacity to adapt to climate change impacts by strengthening livelihood assets;
- increase agricultural productivity and the resilience of rain-fed agriculture by improving water use efficiency and natural resource use;
- adopt a strategy of market-led improvements in productivity that strengthen the competitive ability of smallholder farmers and integrates them into value chains at large scale;
- embrace agro-advisory information and communication technology for farmers;
- demonstrate strong gender targeting;

- reduce the effects of climate change (especially drought) by reducing soil erosion, conserving soil moisture and promoting carbon sequestration;
- incorporate innovative strategies and policies that are specifically designed to enable the wide scale adoption of CSA practices.

Selected successful CSA practices in Africa

Table 1 shows the 17 CSA case studies that are described in this section. These case studies have been selected from across Africa's farming systems, regions and scales of implementation. They are divided into 6 categories.

Table 1: CSA Case studies

Category	**1.1.1 Case study**	**Countries**
3.1. Value chain approach Practices that adopt a value chain approach in tackling risk management and climate variability	1. East Africa Dairy Development Project	Ethiopia, Kenya, Rwanda, Tanzania, Uganda
	2. Systems of Rice Intensification	Madagascar, Mozambique
3.2 Providing multiple benefits Practices that increase productivity, carbon sequestration, rehabilitate degraded lands and build resilience	1. Congo Forest Basin Project	Cameroon, Democratic Republic of Congo, Equatorial Guinea, Gabon, Republic of Central Africa, Republic of Congo
	2. Sustainable Land Management Project	Ethiopia, Uganda
	3. Humbo Community-based Natural Regeneration Project	Ethiopia
	4. Halting the advance of the Sahara desert	Algeria, Burkina Faso, Chad, Djibouti, Egypt, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan
	5. Conservation agriculture in Malawi and Zimbabwe	Malawi
3.3 Increasing crop resilience and productivity Practices that increase crop resilience to drought and increase productivity	1. Drought Tolerant Maize	Angola, Benin, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, South Africa, Tanzania, Uganda, Zambia, Zimbabwe
	2. Water Efficient Maize	Kenya, Mozambique, South Africa, Tanzania, Uganda
	3. Sustainable Agricultural Development of Highlands	Algeria, Egypt, Libya, Mauritania, Morocco, Tunisia
3.4 Promoting gender equity Practices that promote gender equity, and increase women's adaptive capacity and resilience to climate change	1. Anchor Farm Reserve Development Project	Malawi
3.5 Risk management Practices that generate and disseminate agro-advisory services–weather information, insurance, micro-finance, credit and access to markets	1. Africa Risk Insurance Mechanism	Ethiopia, Kenya, Malawi, Mauritania, Mozambique, Niger, Senegal
	2. The Agro-dealer Development Programme	Kenya, Malawi, Tanzania
	3. Programme for Africa Seed Systems (PASS)	Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Tanzania, Uganda, Zambia
	4. National Agriculture Project	Eritrea
3.6 National policies to increase investment - Practices to transform agriculture into a profit-led enterprise	1. National Agricultural and Rural Development Program	Algeria
	2. The Harmonised Seed Security Project	Malawi, Swaziland, Zambia, Zimbabwe

I. Adopting a value chain approach

These projects adopt a value chain approach to tackling risk management and climate variability.

East Africa Dairy Development (EADD) Project

Increasing incomes through improved dairy enterprises, microfinance and markets

The East Africa Dairy Development Project was launched in 2008 in Kenya, Rwanda and Uganda. It aims to assist 179 000 smallholder farming families, each with less than 5acres (2 ha) of land, to participate profitably in the dairy industry. It focuses on improving food security and nutrition, increasing farmers' incomes and facilitating access to markets.

Between 2008 and 2014, monthly milk intake at the dairy enterprises increased from 529 000 to 3 million litres; prices received by farmers also rose from $0.2 to $0.3 per litre of milk. Farmers' access to finance has also improved through a partnership with leading banks, which has enabled farmers to save $11 million by participating in the project.

In Uganda, the project spearheaded the launch of a National Dairy Strategy that aims to double milk production by 2020; in Kenya, 13 financial services associations have been formed, spurring business opportunities. Phase II expands the project to assist a further 136000 smallholder families in Ethiopia and Tanzania, with the aim of doubling their incomes by 2018, and increasing the number of women supplying milk by 30%. Additionally, women are now starting to take leadership roles in their associations and the youth are also actively engaging in the dairy enterprise.

The East Africa Dairy Development Project is funded by the Bill and Melinda Gates Foundation. Over $76 million has been invested in the project in two phases. The project is implemented by Heifer International in partnership with the International Livestock Research Institute, TechnoServe, World Agroforestry Centre (ICRAF), African Breeders Service Total Cattle Management, and farmers.

Although this project was initiated as an agricultural development project, it has great potential for climate adaptation and mitigation (FAO 2012). For example, given the high variability in climate, keeping a large number of livestock in a limited space is a challenge. In such circumstances stall feeding, as promoted by the project, becomes even more appropriate. In addition, the manure from dairy units will be used to produce biogas, which will reduce deforestation, and thus the release of $CO_2$to the atmosphere.

System of Rice Intensification (SRI)

Improving genetic potential at a micro scale

The System of Rice Intensification (SRI) was launched in Madagascar 25 years ago and spread to more than 50 countries worldwide, including Africa, Asia and Latin America. In Africa, SRI is now practised in 20

countries[1]. By 2013, 4–5 million smallholder farmers were using and benefitting from SRI (Vidal 2013, Hoffman 2013). According to the Coalition for African Rice Development (CARD) (2008), the total area under rice in Madagascar is estimated at 1 620 615 ha, of which 1 060 000 ha is under SRI[2].Estimates indicate that between 2005 and early 2012 more than 45248 farmers Madagascar had adopted the SRI practices (COSOP 2012).

In Rwanda, rice production rose from3–4 t $ha^{-1}$to around 7.5 t ha^{-1}between 2006 and 2009, following the launch of the Support Project for the Strategic Plan for the Transformation of Agriculture by the Ministry of Agriculture and Animal Resources. The plan was co-financed by the International Fund for Agricultural Development (IFAD) (Ministry of Agriculture and Animal Resources 2010). In Vietnam, 1 070 384 farmers were using SRI practices on 185 065 hectares by 2011 and have increased their yields by 9–15%. This provided an additional household income of \$95–260 ha^{-1} per crop season. At the same time, Vietnamese farmers reduced their use of agricultural inputs including seed (reduced by 70–75%), Nitrogen (reduced by 20–25%) and water (reduced by 33%) compared to previous practices (Castillo et al 2012).

SRI has been especially successful among resource poor farmers with small rice farms of about 1/3 hectare, because it involves a combination of practices that can be adapted to local conditions by applying three essential principles: plant young seedlings, plant single seedlings, and apply minimal irrigation water to keep the soil just at or below saturation (Uphoff and Fernandes 2002). This creates a favourable growing environment, providing soil, water and nutrient conditions that greatly accelerate growth. SRI focuses on increasing the productivity of major resources including land, labour, finance and water. SRI crops also show more resistance to pests and diseases, tolerance to drought, lodging, hot spells and cold snaps. The length of the crop cycle, especially time to maturity, is also reduced. Introduced in 2009 in Burundi by IFAD, SRI is now practised by about 18 000 smallholder farmers (IFAD 2012).

Globally, farmers have achieved increases in rice grain yields of between 8 and 20 t ha^{-1} on average, increasing from about 2 t ha^{-1}(Ghosh et al2009, Stoop 2011, Uphoff 2012).In Mali, farmers have attained average SRI yields of 9.1 t ha^{-1} compared to 5.5 t ha^{-1} using conventional rice production practices (Styger 2011). The water management technique used in SRI (similar to alternate wet and drying) reduces CO_2 emissions from rice paddies (Uphoff et al 2011, Stoop et al 2002). It is also reported to increase the abundance and diversity of soil organisms by keeping the soil moist but not flooded, aerating the soil frequently and enhancing the soil organic matter content (Uphoff et al 2012). SRI offers water savings for farmers, especially in water scarce areas, as a result of controlled irrigation and alternate wetting and drying (IFAD 2012, Ghosh et al 2009, Stoop 2011, Uphoff 2012).

[1]The 20 countries are Benin, Burkina Faso, Burundi, Cameron, Ethiopia, The Gambia, Ghana, Guinea, Kenya, Liberia, Madagascar, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo and Zambia.
[2] Coalition for African Rice Development (CARD) (2008). National Strategy for the Development of Rice Growing in Mozambique.www.jica.go.jp/english/our_work/thematic.../pdf/madagascar_en.pdf

The success of rice production under SRI prompted organizations such the Better U Foundation to scale up practices by establishing the national SRI network and secretariat for Madagascar, known as Groupement SRI (or GSRI). By 2012, GSRI reported that more than 218 000 farmers are using SRI methods on 63 714 hectares, with yields of 5–6 t ha^{-1}, which is double or triple the typical paddy yield in the same regions. The Government of Madagascar now includes SRI in the design of other climate and development projects. These include the pioneering Carbon Credit Scheme funded by Microsoft, which aims to curb deforestation on 320 000 haof land, and prevent the release of 32.5 million mt of carbon into the atmosphere. The Millennium Village Project also uses SRI to achieve its aim of increasing rice productivity from levels that can sustain a household for 3 months to providing sufficient food for 11 months.

II. Providing multiple benefits

In addition to adaptation to climate change, these projects provide other co-benefits, such as greater productivity, carbon sequestration, rehabilitation of degraded lands and greater resilience.

The Congo Basin Forest Fund

Promoting sustainable forest management by communities and governments

The Congo Basin Forest Fund (CBFF) was launched in June 2008.It is coordinated by the African Development Bank in 10 Central African countries and aims to address climate change across the Congo Basin. This will be achieved primarily by reducing deforestation, forest degradation and poverty through better land use planning; developing sustainable management mechanisms for the natural forests of the region; stabilizing the agricultural sector; and promoting local development.

The project takes two concurrent approaches: a bottom-up approach supports NGOs to assist local communities to implement sustainable forest management, while a top down approach helps government projects design strategies and frameworks to reduce and monitor greenhouse gas emissions from deforestation and forest degradation (REDD+). The CBFF has worked with 85 communities encompassing 14193 direct beneficiaries who have been engaged in producing 57 geo-reference community maps used to influence policy decisions. In addition, the beneficiaries are now aware of their rights, especially in terms of access and control of forest and land resources, as well as their role and involvement in natural resource management.

Among the beneficiaries, 90% relied on woodfuel from the forest as the primary source of domestic energy. With the introduction of agroforestry practices, communities reduced harvesting trees from the forests. In addition, the project also encouraged the use of energy saving stoves and kilns. The project distributed 380 improved stoves and kilns; more than 60% of women within the project adopted the technology. About 1330 women were trained in new fish smoking techniques using less wood energy, leading to a 44% decrease in wood consumption.

In Cameroon two communities, comprising of 1300 people and covering more than 2500 ha, were involved in payments for ecosystem services through the CBFF. These communities have intensified their agriculture by using agroforestry practices and establishing 4 tree nurseries, each with 10 000 seedlings on their farmland to reduce the need for agricultural expansion into the forests, reducing deforestation and degradation. The communities are also encouraged to plant cocoa as part of their agroforestry practices, to help protect the soil and provide products for sale and home consumption.

The impacts of the project are manifold, including improved land management practices, as well as increased yields and incomes from food crops like cocoa through improved tree management techniques. In addition, Cassava yields and income have increased as a result of women sharing improved cassava varieties.

Communities participating in the CBFF are also engaged in collecting, processing, and marketing non-timber forest products, which has contributed to improved livelihoods and sustainable management of trees. For example, women harvest Moabi fruits to extract the valuable oil used for cooking and manufacturing skin creams and other cosmetics. In 2011, some 130 L of oil was produced and sold for $925. Fifty beehives were also installed with the capacity to produce 250 L of honey every year.

The fund received approximately $165 million in funding from the Governments of Norway and the United Kingdom. The fund has also secured a range of multinational projects and additional funding, including 27 NGO-led projects and 13 government-run projects.

Sustainable Land Management (SLM) Project

Preventing and controlling land degradation in sub-Saharan Africa

The Sustainable Land Management (SLM) Project was initiated in 2009 by the Government of Ethiopia to address declining agricultural productivity, the effects of climate change, poverty and food insecurity. It aims to scale up successful practices, approaches and technologies to prevent or control land degradation through integrated and cross-sectoral approaches to sustainable land management.

Phase I of the project, which ended in 2013, was implemented by the Ministry of Agriculture and Rural Development. It received initial funding of $50 million, as part of a total project cost of $95 million. The project will be completed by 2019. Through the project, in targeted watersheds the area of land under SLM practices has increased by about 175 500 ha. More than 96 000 households now use SLM practices, of which 60% have adopted new practices. For 35 project watersheds there has been a 23% increase in the normalized difference vegetation index (NDVI), which quantifies the amount of green vegetation in an area (Jensen 1996). NDVI has shown an annual weighted average increase of3.5%.

In Uganda, the SLM project was launched in 2010, at a cost of $245 million. It is supervised by the World Bank on behalf of IFAD. The project aims to increase agricultural productivity and the incomes of participating households by improving the performance of agricultural research and advisory services in the country. An estimated 20% of Uganda's farmers have benefited from advisory services provided under the

national agricultural advisory services programme. Through SLM, the project aims to expand its outreach to 40–50%of Ugandan farmers, about 1.7 million households.

Humbo Community-based Natural Regeneration Project, Ethiopia

Village level cooperatives plant trees for land rehabilitation and carbon trading

This community-based Natural Regeneration Project was launched in 2007.Implemented by World Vision Ethiopia, it is funded as a Clean Development Mechanism under the Kyoto Protocol by World Vision Australia and the World Bank at cost of $1.3million. Over a 30-year crediting period, more than 870 000 tCO_2will be sequestered.

The project was the first Land Use, Land Use Change and Forestry (LULUCF) carbon trading initiative and targeted almost 49000 people. To date, 2728 hectares of degraded native forest have been protected and restored with a diversity of indigenous species. Through the project, farmers manage natural forest regeneration: this innovative technique has resulted in more than 90% of the project area being reforested from the stumps of trees that were previously cut, rather than replanting trees with costly nursery stock. New tree nurseries have also been established to raise more than 450 000 seedlings each year to restore forests where no living tree stumps remain.

Forest restoration has resulted in increased production of wood and tree products, including honey, medicine, fibre, fruit and wildlife that contribute to household economies. Finally, improved land management has stimulated grass growth, providing fodder for livestock, which can also be sold to provide additional income.

Halting the advance of the Sahara desert

An African alliance to combat desertification and strengthen resilience

This project was launched in 2008, with the aim of supporting national governments and local communities' efforts to sustainably manage and use forests, rangelands and other dryland natural resources. Simultaneously, the project contributes to climate change mitigation and adaptation, and improves food security and livelihoods of the people of the Sahel and the Sahara. The project builds on previous community managed projects such as Farmer Managed Natural Regeneration in Niger, and regional projects such as the African Re-greening Initiative, through which farmers who visited Niger replicated the project in Mali and Burkina Faso. Under the Regional Harmonised Strategy for West Africa coordinated by the Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS), the initiative was scaled up to cover all West African countries that fall within the Sahara and the Sahel.

The project has had widespread impacts in these countries. Farmers have grown 200 million new trees on cultivated fields; those who had only 2 or 3 trees per hectare 20 years ago, now have 40, 60 or even over100 trees. The aggregated value of natural regeneration managed by farmers, and the associated improvements in soil fertility, fodder, food and firewood, has been estimated at $56 $ha^{-1}yr^{-1}$, or a total annual value of

$280 million. These fields contribute an additional 500 000 t of cereals, providing food for about 2.5 million people (Reij et al 2009).

In Mali, farmers in the Seno Plains have protected and managed trees on 450 000 ha of their land: about 90% of the trees are less than 20 years old. Farmers in Senegal's Kaffrine region, have reforested about 30 000 ha, and in Burkina Faso's Central Plateau, between 200 000 and 300 000 ha were rehabilitated, producing about 80 000 t of additional food per year; enough to sustain about half a million people. Here a mechanized technology, known as the Vallerani system, was inspired by traditional practices and has helped to restore more than 50 000 ha of agroforestry systems.

Tree species integrated into the systems, notably *Faidherbia albida*, fix 80– 90 kg N ha^{-1} in the soils and help retain soil cover, enhance fertility and protect the soil from erosion. In Senegal, 27 000 ha of degraded land was reforested with 11 million *Faidherbia albida* trees. The trees are a source of fodder and firewood, and reforestation has reduced the time women spend collecting firewood from 2.5 hours per day 20 years ago, to 0.5 hours today. Re-greening the land has also resulted in an 80% reduction in conflict between herders and farmers.

The project is coordinated by the Comité permanent Inter-Etats de Luttecontre la Sécheressedans le Sahel (CILSS) and has been funded at a cost of$2.4 million by the World Bank, United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), Walloon Region of Belgium, Wallonie-Bruxelles International, ICRAF, and the World Overview of Conservation Approaches and Technologies (WOCAT).

Conservation agriculture in Malawi and Zimbabwe

Building resilience, increasing yields

In Malawi a growing population is placing increasing pressure on agricultural land and farmers are being driven to unsustainable practices at the expense of sustainable resource use.

Total LandCare is promoting conservation agriculture to improve the productivity and profitability, as well as the resilience, of smallholder farming. This involves three core principles of minimal soil disturbance, maintaining good soil cover, and using crop rotation, intercropping, or relay cropping.

On-farm trials show greatly increased yields using conservation agriculture, compared to conventional ridge tillage. From the second season, maize yields were 11–70% higher with conservation agriculture, especially in years of low rainfall. Groundnut yields under conservation agriculture increased by 37–50% compared to conventional tillage.

The number of farmers practising conservation agriculture has risen from 46 farmers in 2005/2006 to 32 896 in 2013/2014; while over the same period the area has grown from 14 ha to 14 155 ha. The challenge is now to scale up conservation agriculture across Malawi.

In Zimbabwe, farmers have shown a growing interest in conservation agriculture, with evidence of yield gains of between 50% and 200% (Mazvimavi and Twomlow 2009, Twomlow et al 2008). It has consistently increased average cereal yields. For example, the mean maize yield on conservation agriculture was 1546 $kgha^{-1}$ compared to 970 $kgha^{-1}$ for conventional draft tillage plots across all 15 districts (Mazvimavi et al 2010).

The project is led by Total LandCare, working with the International Maize and Wheat Improvement Center (CIMMYT), agencies of the Government of Malawi, the National Conservation Agriculture Task Force, NGOs, seed companies and farmer groups. It is funded by the Norwegian Embassy, USAID, UK Department for International Development (DFID) and private companies, with a total budget of $8.5 million.

III. Increasing crop resilience and productivity

These projects focus on CSA practices that increase crop resilience to drought and increase productivity.

Drought Tolerant Maize for Africa (DTMA) Project

Developing and disseminating drought tolerant, high yielding maize varieties

This project was launched in 2006, coordinated by CIMMYT and the International Institute of Tropical Agriculture (IITA). Its objective is to develop and disseminate drought tolerant, high yielding, locally adapted varieties of maize. DTMA has built partnerships between national agencies, non-governmental organizations, seed companies, certification agencies and farmer groups in 13 African countries[3]. As a result of the project, 34 new drought tolerant maize varieties have been developed and distributed to 2 million farmers, whose yields have increased by 10–34%. Farmers have adopted the new varieties and the cumulative economic benefits to farmers and consumers amount to $900million. In the 2011/2012 season, 29 000 t of seed were produced – enough to sow 1.1 million ha and benefit 20 million people.

The Bill & Me Melinda Gates Foundation, Howard G. Buffett Foundation, USAID and DFID have funded the project, with a total budget of $5.8 billion.

The Water Efficient Maize for Africa Project

Improving yields under drought conditions

Water Efficient Maize for Africa (WEMA) was launched in 2008 with the aim of improving food security and livelihoods among smallholder farmers by developing maize hybrids that tolerate drought and resist insect pressures. Coordinated by the African Agricultural Technology Foundation (AATF), CIMMYT and Monsanto, the project operates in Kenya, Mozambique, South Africa, Tanzania and Uganda. The project has released29 maize hybrids that are drought tolerant, early maturing and disease resistant, and these have already been adopted by farmers. A further 84 hybrids have been nominated for national performance trials.

[3] The 13 countries are Angola, Benin, Malawi, Ethiopia, Kenya, Mozambique, Ghana, Zambia, Zimbabwe, Tanzania, Uganda, Mali and Nigeria (CIMMYT 2012)

These maize hybrids yield20–35% more grain under drought conditions than existing commercial hybrids. Some of the maize varieties have also demonstrated resistance to pests such as stem borers.

WEMA was funded by the Bill and Melinda Gates Foundation, Howard G. Buffet Foundation and USAID with a total budget of $1.97 billion.

Sustainable Agricultural Development of Highlands Project, North Africa

Integrating crop, livestock and tree CSA practices in mountainous areas

The Sustainable Agricultural Development of Highlands Project operates in Algeria, Libya, Mauritania, Morocco and Tunisia. The project seeks to improve food security and nutrition while reducing poverty by developing and disseminating new technologies and building capacity to manage cassava, maize, rice, wheat and other high priority crops. In 2013 the project produced more than 8000 t of certified wheat and barley seeds across the region, and facilitated farmers' access to over 750 000 fruit tree seedlings.

In Egypt, high-yielding, rust-resistant wheat varieties were distributed to 2000 farmers across 22 Governorates and improved wheat varieties that can withstand salinity and increase productivity were distributed to 12 African countries. Egypt also released 3 barley and 3 faba bean varieties. A crop–livestock integration system that enhances the availability of animal feed using raised-bed planting was expanded from 1600 ha to 22 200 ha in 2012/2013.

In Morocco, the programme introduced farmers to a no-till technique to conserve water. This boosted wheat yields by at least 25%, and sometimes by 300%, compared to previous methods (Roozitalab et al 2011). Several cultivars of wheat, barley, food legumes and other crops, developed mainly for the lowlands and irrigated agriculture, have been improved and disseminated to farmers to enhance productivity and improve their resistance to pests and diseases in the highland environment of the Atlas Mountains.
The project has received $63 million in funding from the African Development Bank, as well as$24 million in-kind contributions. It is coordinated by the International Center for Agricultural Research in the Dry Areas (ICARDA) and implemented by four CGIAR centres (IITA, AfricaRice, ICARDA and the International Food Policy Research Institute (IFPRI)).

IV. Promoting women's capacity to adapt

These projects emphasize CSA practices that promote gender equity and increase women's resilience in the face of climate change.

Anchor Farm Business Development Project, Malawi

Increasing incomes to support farmers' investment

The Anchor Farm Project was launched in 2008 by the Clinton Development Initiative (CDI) and Alliance for a Green Revolution. It was set up as a commercial farming operation to assist 21 000 smallholder farmers to

access quality inputs for maize and soy production. It provides capacity building on market access, media engagement, and secures extension services for farmers in the Mchinji District of Malawi.

Malawian farmers experience low crop productivity as a result of climate variability and disorganized markets. The Anchor Farm model was introduced to help farmers navigate the markets by growing crops that have market growth potential. Farmers are organized into large groups to run a commercial 1000 ha farm to produce crops. Irrigation schemes were established to adapt to the changing climate and permit cropping throughout the year.

This model is very attractive to women, who are already organized into women's groups and are accustomed to working collectively. The project also works with banks to provide smallholder farmers with access to loans and bank accounts.

About 30 200 farmers, 408 farmer associations, 35 agricultural extension workers and 14 supervisors have been trained on integrated soil fertility management (ISFM) technologies including manuring, composting, crop rotation and conservation farming using nitrogen fixing trees and shrubs in agroforestry systems. Farmers have planted 2 million trees to provide timber, fruits and woodfuel for home use and to provide additional income.

Some 18 000 farmers, half of whom are women, have adopted ISFM technologies and more than 16 000 t of grain was sold through contracts facilitated by the project. Approximately 3200 farmers obtained farm input loans to help them increase their area under soy. At the household level, soy and maize yields have doubled. For soy, prior to the introduction of ISFM practices, women were harvesting about 0.7 t ha^{-1}, which increased to 1.3 t ha^{-1} with the new practices. For maize production, all households increased their yields from 2.3 t ha^{-1} to about 5.0 t ha^{-1}.

Project farmers also receive prices double the normal village level, as a result of negotiations with the contract buyer. The farm gate price for soy, for example, is \$0.32–0.36 kg^{-1}, but women farmers at the Anchor Farm are able to negotiate for a farm gate price of \$0.76 kg^{-1}.

Farmers can use these higher incomes to invest in farm and non-farm business opportunities. Women in particular have greatly benefited from growing soy, because it is a fast growing legume that fetches good market prices compared to other legumes such as common beans, pea and pigeon peas. The income women earn from selling soy is used to buy nutritious foods for their children and families, and to pay for school fees and medical expenses. Women also feed soy to their children to prevent malnutrition and this has increased demand for soy.

The impact of the Anchor Farm Project has prompted the Malawian government to recognize soy as a priority commodity crop for the country, and to strengthen smallholder farmers' – and especially women's – linkages to export markets so they receive better prices.

The project aims to replicate this success in Tanzania at the invitation of the Government of the United Republic of Tanzania. The Government of the Netherlands is providing initial investment to support over 200 000 farmers in Tanzania to establish anchor farms. These farms will help farmers diversify their crops using good quality seed adapted to local weather conditions, and will organize farmers into associations or cooperatives and link them to private sector.

V. Climate risk management through better services

These are projects that promote climate risk management through the generation and dissemination of agro-advisory services, including weather information, insurance, microfinance, credit and access to markets.

Africa Risk Insurance Mechanisms

Managing risk through insurance

The African Risk insurance scheme was set up under the African Union to enable insured countries to plan their response to drought, and prevent it leading to a full humanitarian crisis. The insurance scheme is owned by its members, which include African governments and development institutions such as DFID and Germany's development bank KfW, which have committed up to $200 million. The scheme has issued policies to the governments of Kenya, Mauritania, Mozambique, Niger and Senegal, providing $135 million in drought insurance coverage. Ethiopia, Kenya, Malawi and Mozambique have also experimented with national weather index-based insurance schemes in the crop and livestock sectors. The schemes protect farmers from catastrophic losses as a result of weather events such as droughts, floods and extreme temperatures.

Uptake so far has been mainly on a pilot scale. In 2005 Malawi launched a scheme under which 892 groundnut farmers purchased insurance worth $36 600. As the crop insurance contracts mitigated the weather risk associated with lending, local banks offered loans to insured farmers, who used them to purchase certified seed. The credit thus allowed them to invest in higher yield, higher return activities. In 2007, the pilot was expanded to cash crops and by 2008, participation had increased significantly, as2600 farmers bought policies worth $2.5 million.

In Ethiopia, the weather-based insurance scheme enabled farmers to strengthen their food and income security through a four-part approach: improving natural resource management (community risk reduction); accessing microcredit ('prudent' risk taking), gaining insurance coverage (risk transfer), and increasing savings (risk reserves). In 2012, more than 12 200 farmers in Northern Ethiopia benefited from drought protection and each farmer received a share of the total $322 772 paid through the Horn of Africa Risk Transfer for Adaption Program (HARITA).

In Kenya, Index-Based Livestock Insurance (IBLI) is a pilot programme paying approximately$5800 for losses suffered by farmers' sheep, goat, cattle and camel herds during the long dry season. So far, about 4000 pastoralists in northern Kenya have bought IBLI contracts since the project was launched in 2010. The insurance was linked to a 50% drop in distress sales of livestock and a 33% drop in reliance on food aid.

The Agro-Dealer Development Programme

Better services for farmers through certified agro-dealers

The Agro-Dealer Development Programme provides training, capital and credit to small and medium-sized agro-dealers in several African countries. Agro-dealers are trained to provide agro-advisory information on the best inputs for different agro-ecological zones depending on the season, for farmers who come to purchase inputs such as fertilizers and certified quality seeds that are resistant to pests and diseases. The programme aims to establish or strengthen 10 000 certified dealers of agricultural inputs and seeds across Africa, with a focus on women.

The programme aims to link agro-dealers to wholesalers, seed companies and market information systems. It also advocates for changes to financing policies at the national level so that agro-dealers and farmers can have access to affordable agricultural financing.

In Mozambique 384 agro-dealers have been trained and 19 suppliers of seeds and fertilizers have been linked to retail agro-dealers. In the project area, agro-dealers have sold 5596t of fertilizer and 3883t of improved seeds. 192 000 farmers now use improved seeds, fertilizers, and recommended crop management practices. Thirteen district level agro-dealer trade associations have been created to help agro-dealers sell certified seeds in rural areas with limited government extension services. For the first time 158 agro-dealers gained access to $268 722 in credit through a credit guarantee fund.

Similarly, The Kenya Agro-Dealer Strengthening Programme has increased farmers' access to inputs by reducing the distance they have to travel to reach an agro-dealer from 40 km to 7 km in project districts. In these areas fertilizer use has increased by 30% especially amongst women whose needs are met by the agro-dealers. Women's demands tend to include crop seeds that are mostly grown by women such as local vegetables, as well as vaccines and drugs for chickens.

In Malawi, the programme has trained 1507 rural entrepreneurs and created a strong network of about 400 operational agro-dealer shops. These provide an estimated 150 000 smallholder farmers with access to inputs, technology, finance, extension and links to cash markets.

In all three countries, increased participation by women has been reported, constituting40% of the beneficiaries. Agro-dealers (some of whom are women) are trained with agricultural knowledge and skills specifically targeting the needs of women farmers, appropriate to their domestic and agricultural schedules. Under this programme, women farmers are strongly encouraged to empower other women farmers.

Programme for African Seed Systems (PASS)

Increasing capacity to produce and disseminate quality seeds

This programme seeks to dramatically increase Africa's capacity to breed, produce and disseminate quality seed of staple food crops such as maize, rice, cassava, beans, sorghum and millet that are highly adaptable to diverse climate regimes. It aims to develop seed systems to deliver certified crop varieties that are drought

tolerant, and disease and pest resistant to smallholder farmers efficiently, equitably and sustainably in 13 sub-Saharan African countries. PASS operates through four integrated sub-programmes across the seed value chain. It begins by educating a new generation of plant breeders and seed specialists, and ends with improved seed on the shelves of village level agro-dealers through the Agro-Dealer Development Programme.

The production of certified seed by private companies has increased to 222 535 t since 2007. Forty-one new crop varieties have been released and 83 previously released varieties were brought under cultivation in farmers' fields; in Malawi, Tanzania, Kenya and Zambia 4426 agro-dealers were trained, resulting in sales to farmers valued at $2 million.

This $150 million initiative is funded by the Government of the Netherlands, Bill & Melinda Gates Foundation, The Howard G. Buffett Foundation and USAID Feed the Future.

National Agriculture Project, Eritrea

Better information to support smallholders

This project aims to contribute to national food security and poverty alleviation, particularly among rural households, by increasing smallholder agricultural production and productivity. Using better information to understand rainfall, meteorology and hydrology systems this project has benefited more than 81200 households, of which 20% were female headed households (SoE 2012).

The project is using GIS and satellite imagery to characterize watersheds, as well as improving meteorology and hydrology systems to provide real time information on rainfall. Run-off and river flow data are used as a basis for better control, management and utilization of agricultural water, while agricultural infrastructure is being developed, including soil and water conservation technologies in rainfed areas. Pressurized and spate irrigation areas are also being expanded and improved.

Yields have increased by 300–900% for sorghum and pearl millet, compared with rainfed agriculture in a similar environment (SoE 2012), and farmers have shown commitment to maintaining the spate irrigation structures constructed by previous IFAD-assisted projects.

This programme is funded by IFAD and was launched in 2012 at total cost $26.4 million. It is implemented by the Ministry of Agriculture in partnership with the private sector, National Agricultural Research Institute, Eritrea; Hamelmalo Agricultural College; Agriculture Promotion and Development Department, Eritrea; and the Agriculture and Extension Services.

VI. Investing in CSA

This section describes case studies of national policies for increasing investment in CSA in order to transform agriculture into a profit-let enterprise.

National Agricultural and Rural Development Program (PNDAR), Algeria

In 2002, the Algerian government created the National Agricultural and Rural Development Program. This programme is a comprehensive and coherent response to the challenges and constraints of the natural,

technical, organizational and institutional problems responsible for weakening national food security, degrading natural resources and reducing cohesion and social peace in rural areas (MADR 2007).

Since 2000, Algeria's agricultural sector has recorded a significant annual growth rate of 6.5% compared to 4.0% reported between 1990 and 2000. The plan facilitated an increase in the budgetary allocation to the agricultural sector, which rose by 318% from $1.7 billion (2001–2004) to $7.1 billion (2005–2009). Nonetheless, this figure still only represents 3% of the national budget, considerably less than the 10% recommended by the Comprehensive Africa Agriculture Development Programme (CAADP), endorsed in 2003 by African leaders as the plan of action to put agriculture back onto the development agenda (NEPAD 2003).

In the early 1970s, agriculture was an export sector in Algeria, and 20–30% of total agricultural production was exported. This trend has been reversed, and agricultural exports continue to fall, with the result that only 0.1% of agricultural production is now exported. Between 2000 and 2004, the plan also created more than 900 000 jobs in the agricultural sector.

The Harmonised Seed Security Project

Aligning national seed policies to increase seed availability for smallholder farmers

The Harmonised Seed Security Project (HaSSP) was launched in 2010 to address seed security in the Southern African Development Community (SADC) region. It aims to align national seed policies, in order to increase smallholder farmers' access to high-quality, affordable seed in Malawi, Swaziland, Zambia and Zimbabwe. A major part of the project is the establishment and strengthening of community-based seed production enterprises by smallholder farmers (with a focus on women farmers) in each of the project pilot countries.

Seed variety release and phytosanitary policies in the four countries are now aligned with SADC Protocols. In Swaziland, three HaSSP seed producing communities have been established where two maize varieties are produced and HaSSP has conducted an audit of the seed certification institute (Seed Quality Control Services) to help FANRPAN identify human capacity, knowledge gaps and training needs in Swaziland.

The project is managed by FANRPAN and funded by the Swiss Agency for Development and Cooperation at a cost of $4.8 million.

What's missing from CSA?

The contribution of CSA to resilience in Africa's agricultural systems should not be underestimated. The case studies demonstrate the diversity of CSA practices and the multiple benefits they provide for farmers in the face of climate change. They show that adaptation strategies must be tailored to local conditions and needs, and should encourage sustainable partnerships among public, private, national and international agencies.

CSA is built from many components: practices, technologies, policies, finance, partnerships, institutional arrangements, priority setting, and understanding of local environments (FAO2013). The case studies discussed demonstrate how intimately CSA components are integrated. However, important gaps are emerging:

- **Universities and the private sector are missing**. The case study partnerships included governments, NGOs, donors, development agencies, United Nations agencies, national agricultural research centres (NARCs) and international agricultural research centres (IARCs). Critical partners such as universities and the private sector are largely missing. African universities could become centres of CSA innovation and technology transfer, while the involvement of the private sector could generate investments for CSA research and development. Juma et al (2013) highlight the need for effective partnerships between the private and public sectors, and university-led research.
- **CSA practices are not aligned with national policy.** Projects implemented at a national scale should be aligned with national policy. This creates a more favourable environment for CSA to be incorporated into rural development processes and thus contribute to poverty reduction.
- **Today's youth will become tomorrow's farmers.** Despite this, CSA interventions targeting young people are seriously lacking in all the case studies. Africa's youth account for 60% of all unemployed people (Africa Economic Outlook 2012). CSA practices and technologies can provide employment for young people if national policies to provide access to land, markets, investment and other services are targeted towards them.
- **Innovation by farmers is lacking.** These case studies do not demonstrate innovation by farmers. This is a key element for agricultural transformation in Africa. With the myriad problems facing African farmers, scientists and policy makers must encourage farmers to become actively engaged in CSA innovation.

Priority actions to transform Africa's agriculture

Addressing four challenges at once

In Africa, the quadruple challenges of food insecurity, persistent poverty, climate change and variability, and environmental degradation are closely interlinked. Each factor can be both a cause and an effect. The interactions between these factors occur at local, national, regional and continental scales.

These case studies highlight the need to work at landscape and transboundary levels. Integrated CSA practices operate at a landscape level to enhance food production and provide ecosystem services such as clean water, soil conservation and greater biodiversity. CSA practices that promote greater vegetation cover at the landscape level can contribute to a reduction in soil erosion and encourage increased rainwater filtration into soils and carbon sequestration (Reij et al 2009). This improves soil fertility for crops and grazing.

The Great Green Wall that runs from Djibouti in the east, 8000 km across the continent to Dakar in the west, is an excellent example of local, national and international collaboration, from farmers who plant the trees to international donors. Apart from halting the desert, additional impacts include more diverse sources of food,

easier access to woodfuel, protection of inland waters, restoration of habitats for wildlife, and stronger community resilience to climate change (Reij et al 2009).

Enhancing women's capacity to adapt

Women in Africa face myriad challenges. Women lack access to credit, markets and market information, agro-advisory services, agricultural technology, transport and security of land tenure. Despite these constraints, women continue to provide more than80% of farm and domestic labour (Mohapatra 2011). With the changing climate Africa's women farmers are becoming even more vulnerable.

Yet women's role in food security and land management is central to climate change adaptation. CSA interventions should inform, empower and mobilize women to express their needs, and actively engage them in developing solutions to the problems of climate change. The Anchor Farm project demonstrates the importance of investing in women at all levels from farm production, through credit, to markets for surplus food. By diversifying their livelihood strategies and providing income opportunities, CSA practices can enhance women's capacity to adapt to climate change.

Aligning national policies with CSA

CSA practices need to be aligned with national policy in order to increase smallholders' access to high-quality, affordable seed. Effective national seed policies help farmers access high quality crop seed. Empowering women to access quality seed adapted to local conditions and other services including finance, markets, weather information and agro-advisory services will provide impetus to raise Africa's agricultural productivity. For example, the Harmonized Seed Security Project (HaSSP) is assisting farmers, and especially women, to establish or strengthen community-based seed production enterprises. This is combined with training and extension to help farmers run seed enterprises and capture new seed markets.

The National Agricultural and Rural Development Program in Algeria provides an excellent example of national policies that increase investment in agriculture in order to transform it into an income-led enterprise. The programme aims to expand the area of irrigated agriculture and apply agricultural inputs including fertilizers, quality seed and credit to modernize farms and increase crop production.

Enhancing crop resilience and increasing productivity

Africa is a drought-prone continent, making farming risky for millions of smallholder farmers who rely on rainfall to water their crops. Maize is a staple crop in Africa and more than 300 million people depend on it as their main food source; yet it is severely affected by frequent drought. Insects, particularly stem borers, also have a negative impact on yields, especially during times of drought when they feed on surviving maize and reduce the plants' ability to use limited water and nutrients. Crop improvement using biotechnology offers a powerful tool to achieve significant drought tolerance and stabilize yields.

Lessons Learned

There are successful CSA practices across different regions, countries and communities in Africa that illustrate the efforts of the continent to make agriculture more climate resilient. Through these initiatives, the continent has been able to increase agricultural productivity, income levels and employment opportunities, while contributing significantly to the welfare of women in Africa. Despite the significant progress in CSA, more remains to be done. From these case studies, a number of lessons were drawn.

- **Political good will is fundamental for the success of large projects**

Projects and programmes with government support had significant impacts and were replicated across different countries and regions. For example, the Farmer Managed Natural Resources (FMNR) project has expanded from a single country, Niger, to become the Great Green Wall Initiative. Countries from West Africa with very different politics have planted a band of trees across the Sahel, to restore the soils, halt land degradation, and sequester carbon.

- **Community involvement is critical**

Multi-stakeholder participation – and especially active community involvement – is critical for successful CSA. Projects that had support from governments, local communities and the private sector thrived. For example, through the East African Dairy Development Programme, farmers were directly involved in the project, and with support from the government have registered and now manage 57 dairy business associations. All farmers pool their milk through the associations, which sell to private processing dairies at a better price than is possible in local markets.

Proper coordination and learning by doing are also critical. This was demonstrated by farmers from West African countries such as Burkina Faso, Mali and Senegal who visited farmers in Niger for practical learning about the FMNR project.

- **Information, education and capacity building are essential**

Limited knowledge about promising initiatives can lead to poor uptake of CSA practices. Farmers have been slow to adopt conservation agriculture in Malawi, in part because of a poor understanding of the concept among extension staff as well as farmers. Inconsistent and conflicting advice about conservation agriculture leaves farmers confused. Their misconceptions about how to implement it on the ground, the perceived need for special inputs and tools, and fears about weeds, pests and diseases have put them off trying conservation agriculture.

In Africa, most capacity building programmes are project-based, so when the project ends no resources are available to continue. This results in a lack of capacity to implement CSA practices at all levels.

- **An enabling legal and regulatory framework is necessary**

Public and private institutions need to work together to scale up CSA practices. The public sector must provide the legal and regulatory framework to support private sector innovation and development of new

technologies. For example, although governments may promote micro-insurance, the legal framework still needs to be clarified, including clear directives to foster the design and development of such products. This can support efforts to identify ways of strengthening and standardizing micro-insurance product design and rating.

- **Data are needed to analyse risk:** The lack of reliable data to analyse risk is a major problem for developing insurance systems. Data are critical in the design and rating of any weather insurance program, yet high-quality, long-term time series data on weather, crop production and yield are often not available.
- **National budgetary support is needed:** Most financing of CSA initiatives is based on donor funding, making Africa susceptible to handouts. Given the importance of CSA in national and local economies, African governments need to provide budgetary support for CSA by allocating their own resources to promising initiatives.

Conclusions: building on successful CSA practices

Climate change is already affecting Africa's agriculture. African farmers, especially women, need to be equipped with the knowledge and skills to combat the impacts of climate change. CSA is critical to the long-term sustainability of Africa's farmlands.

These case studies have demonstrated that CSA is critical to help Africa increase agricultural production and incomes, adapt to climate change, build resilience and reduce greenhouse gas emissions. African leaders must commit to investing in CSA and policies that support agricultural development, combat hunger and land degradation. They also need to create partnership opportunities for scaling up CSA practices at local, national, regional and continental levels.

Despite the major successes of these case studies, adoption will continue to be low and impact will remain limited if governments do not invest in scaling-up projects and knowledge dissemination. Governments and their strategic partners, especially the private sector and agro-advisory service providers, must provide sufficient incentives to encourage farmers to invest in CSA practices and technologies.

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