WORLD BANK GROUP

Climate-Smart Agriculture Implementation Brief

A Summary of Insights and Upscaling Opportunities through the Africa Climate Business Plan

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TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1

Introduction

Climate change and food insecurity are the twin development challenges that may define Africa's future. About 277 million, or one in five, people are undernourished in the continent due to lack of sufficient or nutritious food. This number could increase to 350 million by 2050 if appropriate adaptation measures are not taken to cope with the intensity of future climate change (World Bank 2013b). Climate change has been reducing yields and causing more frequent extreme weather events. In 2016, the food security situation deteriorated sharply in Africa, especially in East and Southern Africa, due to droughts and floods linked in part to El Niño/La Niña–related phenomena. A projected rise in extreme weather events and average temperatures of about 2°C by the middle of the century could substantially reduce the land suitable for growing the main staple crops and reduce crop yields by up to 20 percent.

The Africa Climate Business Plan (ACBP) was launched by the World Bank at the 21st Session of the Conference of the Parties (COP 21) in Paris in 2015 to address Africa's intricately linked climate and development agendas. The ACBP calls for US$19 billion in funding to help Africa adapt to climate change and build up the continent's resilience to climate shocks. The ACBP includes a focus on climate-smart agriculture (CSA), an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change. CSA comprises three pillars: (a) increasing productivity, (b) enhancing resilience and adaptation, and (c) reducing greenhouse gas (GHG) emissions from the agriculture sector compared to past trends.

The ACBP aims to build a pipeline of innovative and transformational projects to address climate change and establish a platform to mobilize investments, thereby contributing to filling the climate financing gap in the region. Table 1 provides data on the implementation of the CSA component of the ACBP. From January 2016 to January 2020, the World Bank's Board approved 137 projects supporting CSA with a cumulative cost of US$6.8 billion. The projects are spread across 35 countries in Africa and aim to improve the livelihoods of 9.1 million farmers and increase the climate resilience and productivity of more than 9.8 million ha of land (table 1).

African countries are adopting a range of context-specific climate-smart technologies and practices to meet their food security and climate change goals. Improved livestock production is the most prevalent practice in the CSA portfolio, followed by improved water management, conservation agriculture, agroforestry, and, notably, digital agriculture (figure 1). The application of digital technology in the design and delivery of integrated weather and market advisories using big data analytics is increasingly helping countries identify conditions that may endanger food security and inform farmers' decisions to adequately respond to and, when possible, capitalize on, the changing conditions (see Chapter 5).

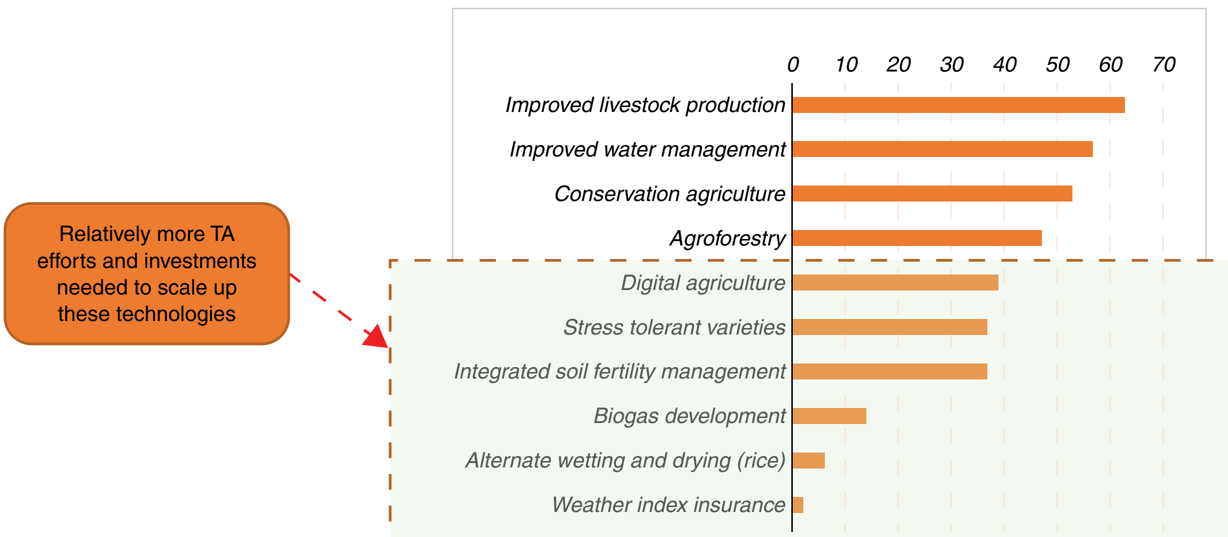
Total climate co-benefits were about US$3.0 billion, with 64 percent of the financing (about US$2.0 billion) flowing into adaptation (table 1). Higher finance flows to adaptation compared to mitigation reflect the priorities of African countries to address the sector's climate vulnerability and increase resilience. Compared to estimates as at September 2018, the proportion of finance flowing into climate mitigation increased slightly from 34 percent to 36 percent in January 2020, suggesting that countries are increasingly paying attention to the vast potential for African agriculture to reduce agricultural emissions through climate-smart practices. While the CSA technologies show promise of co-delivery of adaptation and mitigation benefits, the major agricultural mitigation benefits derive from

TABLE 1: Data on the Implementation of the CSA Component of the ACBP

Period	All IBRD/IDA Projects with Agriculture Sector Components		Of Which, Projects with Climate Co-benefits					
	No.	Cost (US$, millions)	No.	Total Co-benefits (US$, millions)	Adaptation Co-benefits (US$, millions)	Mitigation Co-benefits (US$, millions)	Farmers Reached with CSA	Land Area (ha) Under CSA
January 16–September 16	18	821	11	435	238	197	1,211,400	558,382
October 16–September 17	48	1,925	31	756	538	218	3,104,787	2,353,328
October 17–September 18	41	1,982	22	732	541	191	2,377,300	1,048,208
October 18–January 20	30	2,132	19	1,054	592	462	2,385,446	5,822,726
Total	**137**	**6,861**	**83**	**2,977**	**1,909**	**1,068**	**9,078,933**	**9,782,644**

Source: World Bank.

FIGURE 1: Prevalence of CSA Technologies in the ACBP Portfolio (%)



Source: World Bank.
Note: TA = Technical assistance.

agroforestry, improved livestock production and pasture management, conservation agriculture, and integrated soil fertility management.

Following the background and context provided in this chapter, Chapter 2 of this brief reveals the central role of CSA profiles and investment plans for scaling up CSA, with countries with CSA profiles or investment plans accounting for more than 80 percent of investment. Chapter 3 provides insights from CSA investment plans (CSAIPs) for Lesotho, Côte d'Ivoire, and Zimbabwe, three front-runners in the preparation of investment plans. Chapter 4 illustrates how countries are using CSA to build resilience and mitigate carbon emissions, while Chapter 5 concludes with recommendations to enhance efforts to scale up CSA for transformational change in Africa.






CHAPTER 2

CSA Country Profiles and Investment Plans Are Major Drivers of Upscaling

CSA stresses the importance of building evidence to identify viable options and necessary enabling environments for effective implementation (Lipper et al. 2014). The current evidence base is grossly inadequate to support effective decision making and largely inaccessible to decision makers. Furthermore, there is a major gap in the evidence base concerning barriers to the adoption of agricultural practices that respond to climate change and measures of overcoming these barriers. Mainstreaming CSA requires critical stocktaking of ongoing and promising practices for the future and of institutional and financial enablers for CSA adoption.

To strengthen the evidence base for CSA implementation, the World Bank and other development partners are actively supporting countries in the preparation of CSA country profiles and CSAIPs.[1] The CSA profile provides baseline information for initiating discussion about entry points for investing in CSA at scale. It characterizes a country's climate vulnerability, specifies promising CSA technologies and level of adoption, and documents institutions and policies for CSA. The CSAIP takes the information provided by the profile further by identifying investments that offer the greatest potential to transform a country's agriculture sector into a more productive, climate-resilient, and low-emissions sector. It identifies potential pathways for scaling up CSA, the impact of various factors on adoption, and policy actions required to support effective scaling up.

Currently, CSA profiles or investment plans have been prepared for 22 countries (figure 2), with Investment Project Financing initiated in 17 of these countries. Table 2 shows that the profiles and investment plans are major drivers of CSA investments in Africa. Between January 2016 and January 2020, the total number of projects in the 17 countries was 47, about 34 percent of the entire portfolio. The 47 projects account for US$5.6 billion (that is, 82 percent) of the entire portfolio's total cost of US$6.8 billion, with climate adaptation and mitigation co-benefits (finance) accounting for 77 percent and 79 percent, respectively.

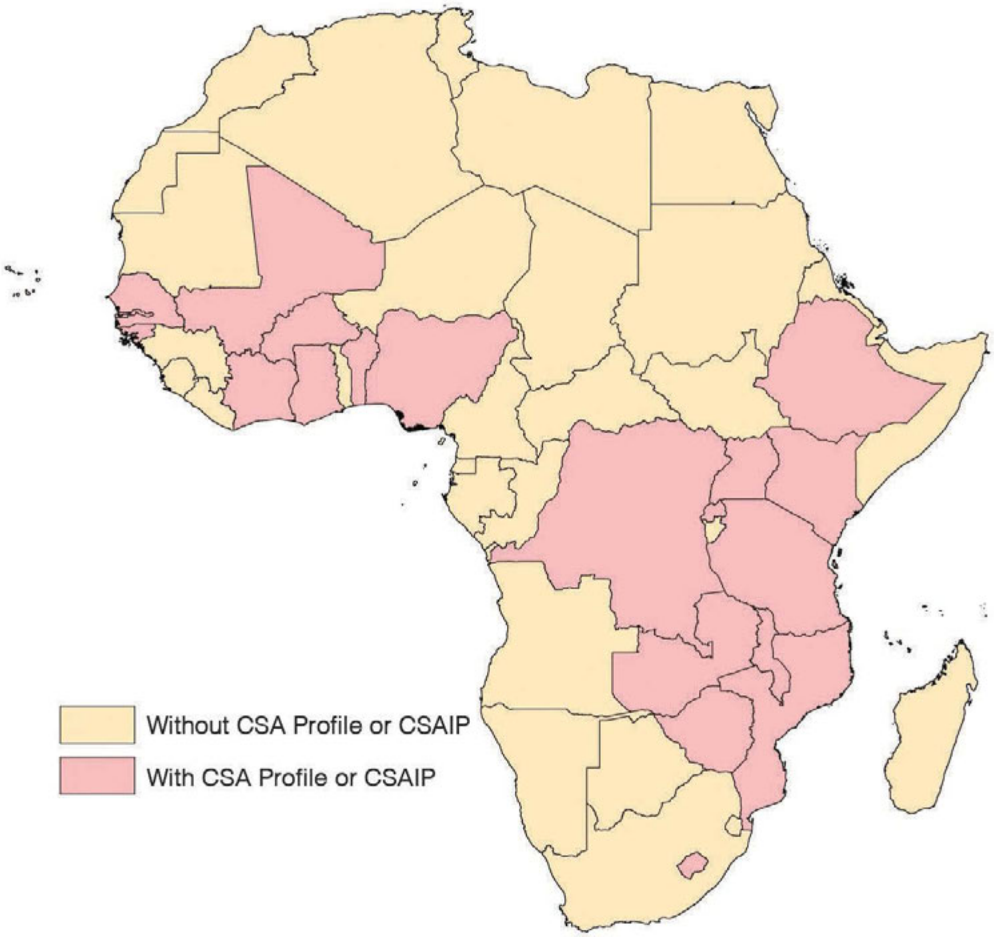
TABLE 2: Agricultural Climate Finance in Countries with CSA Profiles and CSAIPs (US$, millions)

	No. of Projects	Cost	Total Agricultural Climate Finance	Agricultural Adaptation Co-benefits	Agricultural Mitigation Co-benefits
Countries with CSA profiles or CSAIPs	47	5,597	2,319	1,473	846
Entire portfolio	**137**	**6,861**	**2,977**	**1,909**	**1,068**

Source: World Bank.

1 For country profiles, see https://ccafs.cgiar.org/publications/csa-country-profiles; for CSAIPs see https://www.worldbank.org/en/topic/agriculture/publication/climate-smart-agriculture-investment-plans-bringing-climate-smart-agriculture-to-life and relevant references in this Brief.

FIGURE 2: Countries with CSA Profiles or CSAIPs



Source: World Bank.

CHAPTER 3
Insights from Selected CSAIPs

CSAIPs help in identifying and prioritizing locally appropriate CSA technologies that address the context specificity of a country's agricultural systems. A CSAIP is usually prepared following four steps that combine participatory bottom-up approaches with quantitative modeling. The first step entails the identification of a vision and goals for the country's agricultural sector. The second step involves scenario development to identify agricultural development pathways and key uncertainties that can impede the achievement of sector goals. The third step involves modeling to assess the productivity and climate benefits of CSA under a changing climate, while the last step involves prioritizing technologies, evaluating strategies, and determining investment requirements. This brief documents the major findings from applying this analytical approach for Lesotho, Côte d'Ivoire, and Zimbabwe.

3.1 LESOTHO: THE COMMERCIALIZATION AND RESILIENT LANDSCAPE PATHWAYS

The Lesotho CSAIP provides evidence that the adoption of CSA offers multiple wins: increased productivity and incomes; enhanced food security and dietary diversity; reduced impacts of climate change on agricultural produce; and improved commercialization, employment opportunities, and rural livelihoods (World Bank Group 2019a). The CSAIP shows that CSA can also reduce soil erosion, generate carbon sequestration, conserve biodiversity, and provide other public goods that accrue to society—well beyond the farmers engaged in market transactions alone.

The CSAIP offers two complementary pathways for scaling up CSA in Lesotho. The first is the commercialization pathway that entails focusing on commodities for which the country has distinct comparative advantages, such as horticulture, potato, and aquaculture; developing the country's irrigation to its full potential; and developing links between smallholders and exports, as well as domestic markets.

The second is the resilient landscape pathway that combines modern scientific practices such as improved crop varieties with the traditional Machobane farming system that combines the use of crop rotation, relay cropping, and intercropping practices with the application of manure to conserve soil moisture and replenish soil fertility. The resilient landscape pathway primarily focuses on investing in sustainable landscape and integrated catchment management and strengthening local institutions to enhance landscape resilience.

The commercialization pathway is often more profitable. It requires larger farms; takes up less land for the same amount of production; creates more jobs; produces more food calories; and offers Lesotho the potential to export horticulture, potato, and vegetables (table 3). It also requires strong market-oriented agricultural policies for it to be successful.

On the other hand, a resilient landscape pathway is often more effective in controlling land degradation and delivers about ten times more carbon benefits compared to commercial agriculture. Thus, compared to the commercialization pathway, the resilient landscape pathway could potentially benefit more from climate finance, which can come from a variety of sources including the United Nations Framework Convention on Climate Change (UNFCCC) funding mechanisms, multilateral and bilateral funds, national and regional climate funds, and private sector investments.

TABLE 3: Comparison of Indicators for Commercialization and Resilient Landscape Pathways

Indicators	Commercialization	Resilient Landscape
Net household income (US$ per year)	1,233	698
Average increase in crop yields over historical (%)	60	70
Cropland area (ha)	132,247	153,482
Livestock production (ton)	38,849	45,765
Erosion control: gross erosion (Mt per year)	39	35
Food availability[2] (kcal/capita/day)	675	649
Export potential	Moderate	None
GHG mitigation: carbon balance tCO_2e	–2,521,976	–26,228,494
Job creation	39,378	27,862
Economic internal rate of return (EIRR) %	32	13
Carbon benefits (US$, millions)	2–17	36–282
EIRR % with carbon benefits	32–34	16–73
Financial cost (US$, millions)	208	268

Source: World Bank 2019a.
Note: Green indicates that a scenario performs better; orange indicates otherwise.

3.2 CÔTE D'IVOIRE: TARGETING DELIVERY MECHANISMS AND COMMODITY-SPECIFIC INVESTMENTS

The Côte d'Ivoire CSAIP emphasizes strengthening agriculture across Côte d'Ivoire, with four national-level investments and eight commodity-specific investments in all major agroecological zones (World Bank Group 2019b). The four national-scale initiatives that are foundational to an adaptive and climate-smart agricultural sector are agrometeorology, finance services, soil fertility, and agricultural extension. An agrometeorological system increases farm productivity and mitigates climate-related risks by providing timely, accurate agrometeorological information to producers, extension agents, and agribusiness. Agricultural financial services can potentially increase productivity sustainably by improving agricultural producers' access and ability to leverage financial products and services that are vital to managing climate-related risks. Soil fertility management services provide agricultural producers and extension agents with location-tailored information on soil characteristics and recommendations on best management practices. Lastly, agricultural extension services improve the quality of CSA-informed recommendations that will ultimately increase farm productivity and enhance resilience.

The eight climate-smart agricultural produce prioritized to support adaptation of agricultural production systems include cassava, vegetables, cocoa, livestock, mango, maize, rice, and yam (table 4). Their prioritization was based on several context-specific factors including on-farm importance, the value of the commodities within the Ivorian economy and society, the response to climate change, likely trends without interventions, and the intended emphasis of the investment.

2 This measures food calories from national production.

TABLE 4: Rationale for Prioritization of Commodity Investments

CSA Investment	On-farm Importance	Ivorian Importance	Projected Response to Climate Change	What Could Happen in the Future without CSA Investments	Response: Investment for Improving Resilience, Expanding Growth, or Both
Cassava	Food security	35% of daily calories (with yam) and grown by 85% of smallholders	Relatively resilient	Yield stable, little growth to meet higher demand	Growth
Abidjan food system (vegetables)	High economic value	Address growing demands of rapid urbanization	Bad	High demand, so increased imports	Resilient and growth: reducing import need
Cocoa	High economic value	Employs 15% of Ivorians	Small decline	Lower yields, expansion to forests, lower export revenue	Resilient and growth: expanding exports
Livestock	High nutritional value and food security	Produced by 58% of rural population, including 800,000 pastoralists	Moderate decline	Environmental degradation, conflict, reduced productivity	Growth
Mango	Food security	Largest exporter in West Africa: 50% consumed domestically	Small decline	Lower yield and small production	Growth: expanding yield and value added
Maize	Food security	21% of daily cereal consumption and 36% of all cereals grown now	Very bad	Serious declines	Resilience and growth: toward self-sufficiency
Rice	Food security	61% of daily cereal consumption and 45% of all cereals grown now	Small decline	Slight decline in production	Resilience and growth: toward self-sufficiency
Yam	High-value nutrition	35% of daily calories (with cassava)—largest crop area	Small increase	Slight increase in yield but not enough to meet higher demand	Resilience and growth: expanding yield and value added

Source: World Bank Group 2019b.

3.3 ZIMBABWE: CSA INVESTMENT PACKAGES ADAPTED TO THE ENABLING ENVIRONMENT

Zimbabwe's CSA goals identified by stakeholders include achieving food and nutrition security through a diversified, sustainable, and commercially driven agricultural sector; ensuring that the agricultural sector is resilient to climate shocks by 2030; and achieving a sustainable agricultural sector that reduces GHG emissions through carbon conservation and carbon sequestration (World Bank Group 2019c). Initially, a long list of investment packages made up of combinations of individual CSA options was developed. These short-listed packages were subsequently evaluated by local and international experts across nine different criteria, divided into two categories: those that move Zimbabwe toward achieving the CSA goals and those that have the necessary elements of the enabling environment in place to successfully implement CSA in the country.

The Zimbabwe CSAIP finally recommends five high-priority investment packages capable of advancing these goals: (a) enhanced agricultural knowledge and innovation system, (b) sustainable livelihoods through diversified livestock systems, (c) water harvesting for resilient crop and livestock production, (d) women- and youth-focused value chain development, and (e) resilient commercial dairy farming (table 5).

TABLE 5: Priority Investments for the Zimbabwe CSAIP

Investment Opportunities	Impact Potential	Investment Volume
Package A: Enhanced agricultural knowledge and innovation system		
• Build capacity of public extension workers • Invest in innovation platforms based on strong public, private, and civil society service partnerships • Invest in ICT-enhanced information dissemination systems	• Improves smallholder farmer productivity and resilience in crop production (maize, small grains, and horticulture) • Switching to improved crop varieties increases yields by 5–20% • Increase incomes, nutrition security, and resilience, particularly in Agro-ecological Regions IV and V • Moving away from monocultures increases soil carbon sequestration	US$50–75 million or US$83–125 per beneficiary
Package B: Sustainable livelihoods through diversified livestock systems		
• Invest in improved/alternative flooding systems • Climate-resilient breeding program and extension services • Commercialization of livestock in the smallholder farmer sector	• Improved feeding practices reduce livestock feed intake by 53% • Improved feeding practices reduce livestock methane emissions by 56% • Using velvet beans could increase profiles for non-daily cattle farmers with benefit-cost ratio of 1.5–1.9 • Switching to smaller livestock increases protein production, provides a more climate-resilient food source, and significantly reduces GHG emissions	US$30–60 million or US$100–200 per beneficiary
Package C: Water harvesting for resilient crop and livestock production		
• Invest in soil and water conservation techniques as part of integrated catchment management • Invest in water harvesting and small-scale water infrastructure to enhance crop and livestock production • Build the capacity of extension workers and farmers in sustainable water harvesting practices, including water conservation and conservation agriculture	• Improved water availability results in increased livestock and crop productivity, which increases farmer income • If conservation tillage were adopted in Agro-ecological Region V, soil carbon sequestration would decrease emissions by 6,400 tCO_2e per year • Mulching reduces soil evaporation after rainfall by 15–24% • Irrigation for maize results in 4.5 greater yield in Agro-ecological Region V	US$75–100 million or US$95–125 per beneficiary
Package D: Women- and youth-focused value chain development		
• Organic vegetable, poultry, and goat production in peri-urban areas around Harare • Promote sustainable financial inclusion for women and youth • Invest in women- and youth-oriented production and marketing networks	• Enhances income and food security among women- and youth-owned farms • Increased productivity of high-value vegetables and poultry • Comparable projects suggest up to 30% lower livelihood of malnourished children to mothers involved in urban farming	US$20–40 million or US$330–670 per beneficiary
Package E: Resilient commercial dairy farming		
• Improved food and fodder production • Breeding programs for climate-resilient dairy cow breed • Provision of robust extension services • Climate-smart production for milk and cold chain management	• Boost productivity of commercial A2 dairy farmers, reducing milk imports and increasing farmer income and food security • Improving on-farm conditions can result in increases in milk output of 7.8 times • Reduced malnourishment in children • Job creation based on higher productivity	US$30–60 million

Source: World Bank Group (2019c).
Note: ICT = Information and communication technology.





CHAPTER 4

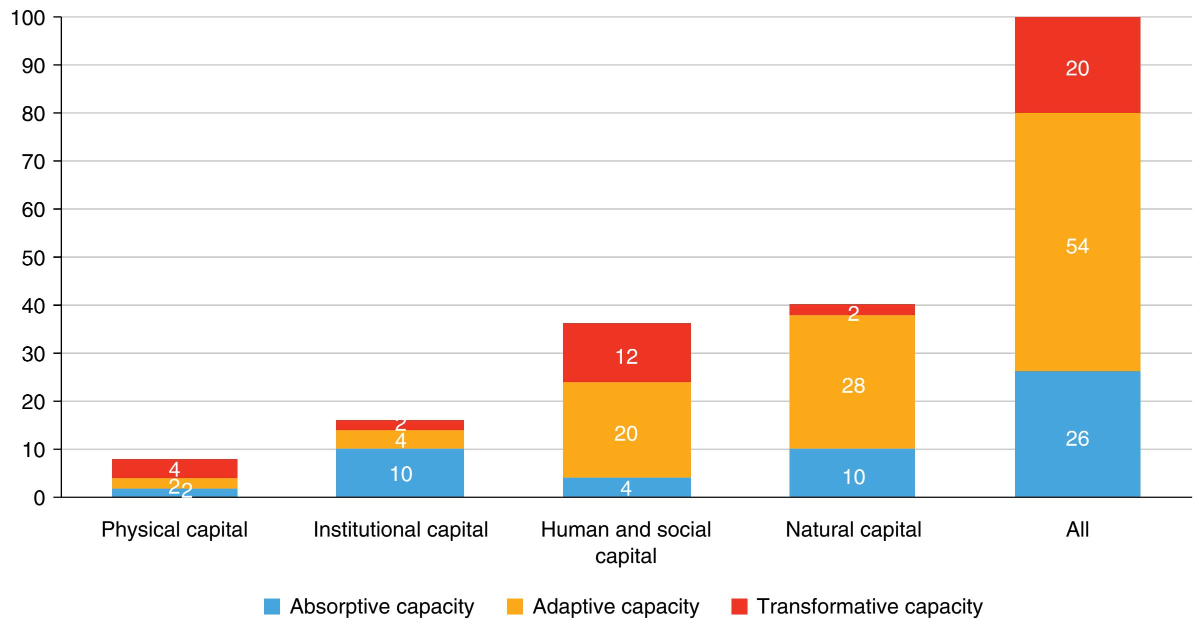
Using CSA for Achieving Climate Resilience and Mitigation

4.1 BUILDING RESILIENCE CAPACITY THROUGH CSA

A major goal of the ACBP is to deliver on CSA at scale to increase the efficiency and resilience of food systems in Africa. Resilience can be defined as the capacity of social, economic, and environmental systems to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation (IPCC 2014; World Bank Group 2018a).

Developing adaptive capacity, defined as the ability of a system to adjust, modify, or change characteristics and actions to moderate potential future impacts from hazards through incremental changes, is the primary focus of resilience building (54 percent of project activities) in the ACBP portfolio. Boosting absorptive capacity, the ability of a system to prepare for, mitigate, or prevent negative impacts of hazards, is addressed by 26 percent of project activities, whereas increasing transformative capacity, the ability to create a fundamentally new system to avoid negative impacts from hazards, is focused on by 20 percent of project activities.

FIGURE 3: Distribution of CSA Project Activities across Types of Capital and Resilience Capacities Strengthened (%)



Source: World Bank.

Resilience is closely linked to securing or maintaining a sustainable livelihood and is dependent on access to, or improvement of, a range of livelihood resources (assets), namely, human, natural, physical, social, and institutional capital (DFID 2000; Su, Saikia, and Hay 2018). Livelihood assets constitute a stock of capital that can be stored, accumulated, exchanged at the community or household level, and deployed to minimize climatic impacts (table 6).

TABLE 6: Livelihood Capital and Examples of CSA Project Activities

Capital	Description	Examples
Human capital	Personal development ability, including education, skills, and technical competence essential for the development and practical application of relevant knowledge	Farmer field schools, demonstration plots, and integrated weather and market advisory services
Natural capital	Stocks of natural assets including soil, air, water, and all living things that sustain life	Conservation of protected areas, capturing biogas from anaerobic processes, integrated soil fertility management, and community agroforestry
Physical capital	Man-made goods that assist in the production process rather than being outputs themselves	Climate-resilient flood control, structural measures for erosion protection, silos for grain storage, and irrigation equipment
Social capital	Ability of farmers and other actors to secure benefits by virtue of membership in social networks or other social structures	Farmers' cooperative, social protection system, and water user associations
Institutional capital	Formal and informal institutions that reduce uncertainty which, combined with other resources, influences agricultural outcomes	Farmer Input Support Program and Warehouse Receipt System

Source: Synthesized from World Bank Project Appraisal Documents.

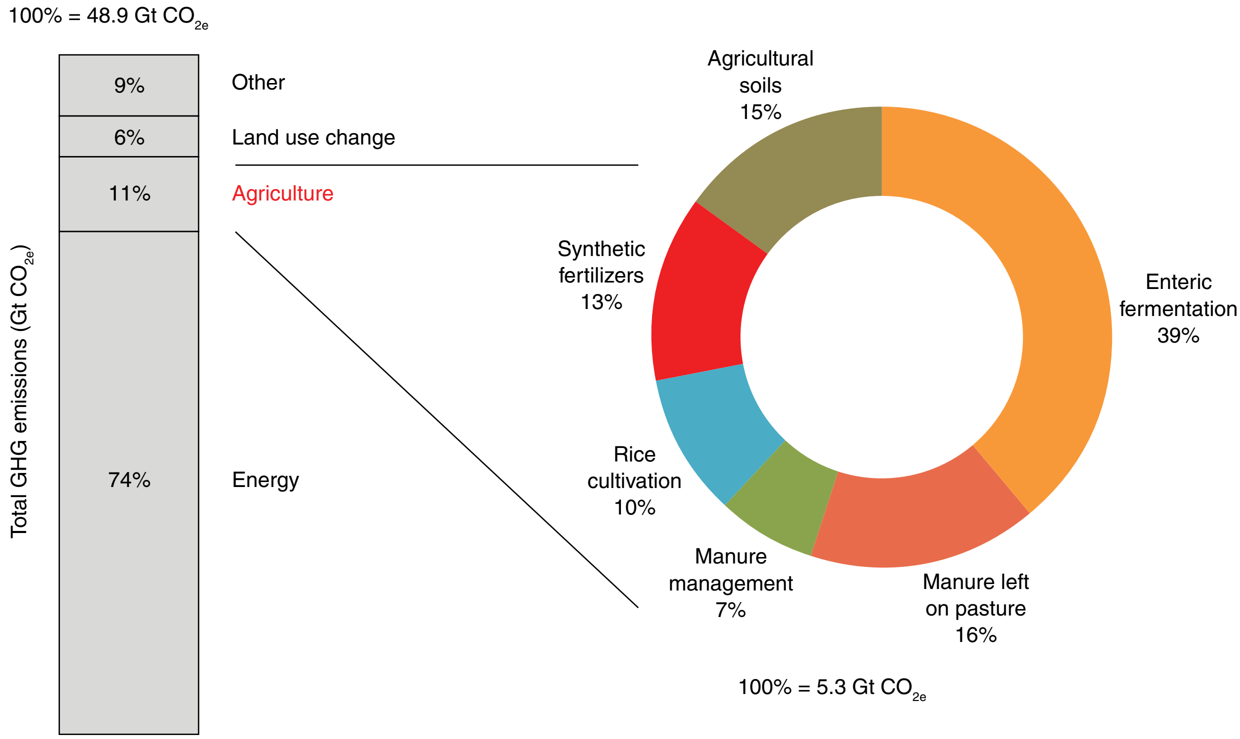
In terms of livelihood capital, figure 3 indicates that the project activities focus mainly on building natural capital (40 percent), followed by human and social capital (36 percent), institutional capital (16 percent), and physical capital (8 percent). Increased efforts to build human capital through training and skills development will help address the capacity gap, a critical barrier to the adoption of CSA technologies. There is a need to invest more in institutional capital through policy development and enhanced private sector participation. More effort is needed to promote market system interventions to build resilience to climate change. Projects using a market systems approach focus on strengthening value chains and identifying market opportunities for the smallholder farmers. One of the reasons that such approaches are popular is that they aim to mobilize private sector resources for development, rather than relying solely on limited public sources of finance, and thus are viewed as more sustainable than other approaches.

A mix of absorptive, adaptive, and transformative capacities is often needed to deliver resilient development outcomes, but the proportions in the mix depend on the system's needs and the climate change impacts that require increased resilience. Interventions to increase absorptive and adaptive capacities are often the first and quickest way to increase the climate resilience of smallholder farmers and rural communities. However, given the intensity, frequency, and pace of climate change and the extreme vulnerability of African agriculture, resilience building also needs to include more transformational responses to support deep, systemic, and sustainable change with the potential for large-scale impacts across Africa.

4.2 GREENHOUSE GAS MITIGATION THROUGH CSA

Global GHG emissions reached 48.9 gigatons (Gt) CO_2e in 2016 (FAOSTAT 2016; WRI 2020). The energy sector contributed 74 percent to total GHG emissions, followed by agriculture and associated land cover and land use changes, which contribute 8.5 Gt CO_2e per year (about 17 percent) of total GHG emissions globally (figure 4). Of the 5.3 Gt CO_2e per year (about 11 percent) agricultural contribution to global GHG emissions, enteric fermentation (39 percent), manure left on pasture (16 percent), agricultural soils (15 percent), and synthetic fertilizers (13 percent in agriculture) are the main emitters in the agriculture sector.

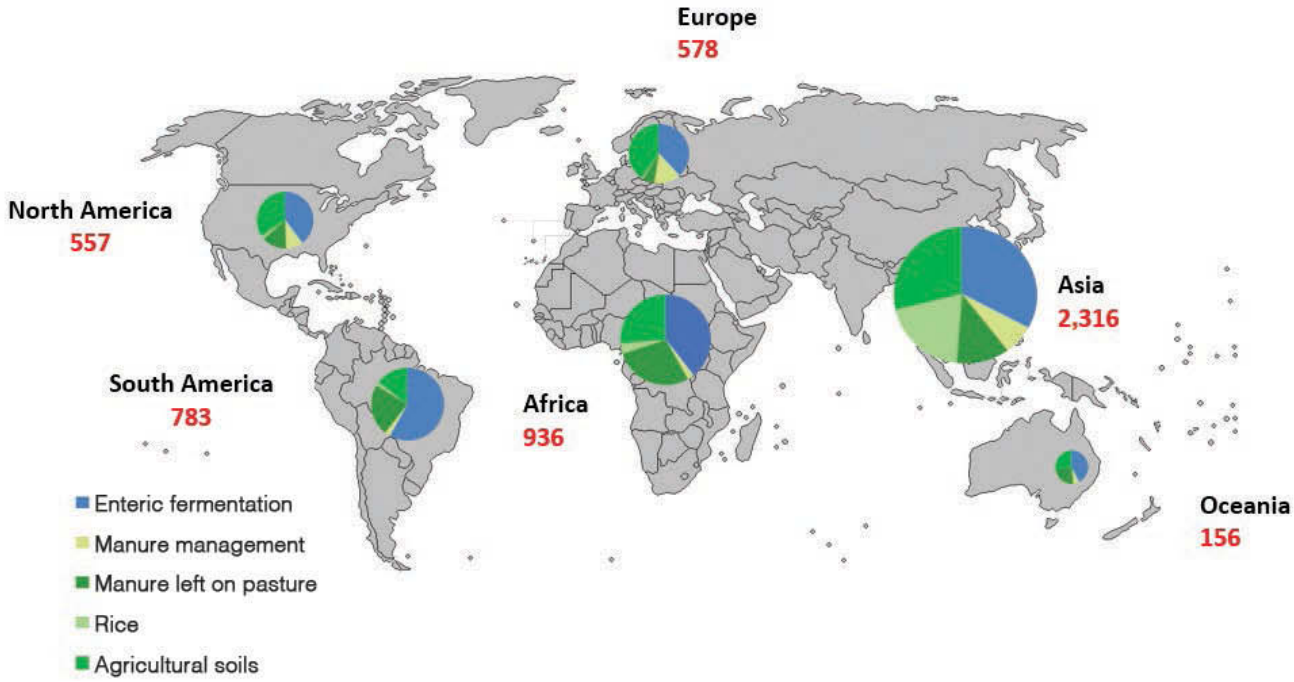
FIGURE 4: GHG Emissions from Different Sectors



Sources: FAOSTAT 2016; WRI 2020.
Note: Global agricultural emissions: Agriculture and associated land cover and land use changes contribute 8.5 Gt CO_2e/y (about 17%) of total GHG emissions globally.

In terms of regional emissions, figure 5 shows that Africa is the second emitter, releasing 936 Mt CO_2e or 18 percent of global agricultural emissions annually. Agriculture is the sector with the largest source of GHG emissions in Africa, accounting for about 58 percent of emissions in the continent. Livestock contributes primarily to agriculture emissions in Africa, accounting for about 655 Mt CO_2e or 70 percent. Out of the livestock-induced emissions in Africa, enteric fermentation contributes about 40 percent, followed by manure left on pasture (about 28 percent), while manure management contributes about 2.4 percent. The second-largest category of agricultural emitter in Africa is agricultural soils, which contribute 221 Mt CO_2e (about 24 percent) of total agricultural emissions.

FIGURE 5: Agricultural Emissions by World Regions (Mt CO_2e per year)



Source: FAOSTAT 2016.
Note: Area of pie charts has been scaled to regional emissions.

Quantifying GHG emissions from agricultural production is a necessary step for climate mitigation through CSA. GHG accounting can provide the numbers and data that are important to solid decision making for low carbon agriculture. It will help identify management practices and opportunities that reduce GHG emissions while also providing improved food security, more resilient production systems, and better rural livelihoods. In practical terms, GHG emissions data can support farmers in adopting less carbon-intensive practices, guiding low-emissions development, assessing product supply chains, certifying sustainable agriculture practices, and informing consumers on the carbon footprint of their choices (Olander et al. 2013).

Table 7 shows that over the economic life of a project ranging from 12 to 20 years, the estimated gross GHG emissions of the World Bank's CSA portfolio were 1.3 Gt CO_2e. The implementation of climate-smart practices lowers the emission to 887 Mt CO_2e, implying substantial net emission reduction of about 467 Mt CO_2e. This emission reduction is equivalent to taking more than 99 million passenger vehicles off the road in one year or avoiding the burning of more than 233 Mt of coal (www.epa.gov).

TABLE 7: Estimate Carbon Balance of the Agriculture Portfolio (Mt CO_2e)

Over the Economic Life of the Project			Annual Average		
'Without Project' Scenario (1)	'With Project' Scenario (2)	Net Emissions (2 – 1)	'Without Project' Scenario (3)	'With Project' Scenario (4)	Net Emissions (4 – 3)
1,331.40	887.44	–466.62	57.32	38.48	–19.75

Source: World Bank.

CHAPTER 5

Opportunities for the Future

Climate change presents enormous challenges and opportunities for development, making it essential that climate and development be tackled in an integrated way. The World Bank—through the CSA portfolio of the ACBP—is advocating and working with stakeholders to foster adoption of CSA policies and finance investment programs to scale up and intensify CSA technologies. More governments are now committing to a more sustainable, climate-smart food system as CSA continues to gain momentum in the region. Experiences in and lessons from Africa could eventually have an impact beyond the region and be instructive for countries around the world. This chapter presents three recommendations to enhance efforts to scale up CSA for transformational change in Africa.

5.1 PROMOTE INTEGRATED LANDSCAPE MANAGEMENT

In addition to raising smallholder agricultural productivity through context-specific CSA technologies, there is a need to urgently address the ongoing land degradation in the continent. Land degradation refers to the loss of the productive capacity of land due to a combination of human-induced factors such as soil erosion, acidification, nutrient leaching, and compaction. It is linked to poor land and water management, deforestation, and poorly designed socioeconomic policies. Land degradation interacting with climate change represents one of the biggest and most urgent challenges for Africa, with profound implications for food production, food security, natural resource conservation, and economic development. Half of Sub-Saharan Africa's populations, three-quarters of the poor, live in drylands that are particularly susceptible to land degradation and desertification processes (IPCC 2019). Land degradation costs about US$108 per person each year or an estimated annual 12 percent gross domestic product (GDP) loss for 19 countries in Africa (table 8). Smallholder farmers suffer the most because poor soil conditions, climate and weather variability, land tenure insecurity, and limited access to markets pressure them to make short-term trade-offs that compromise long-term gains. Land degradation reduces options to meet both food demands and environmental needs sustainably.

TABLE 8: Integrated Landscape Management Indicators for Selected African Countries

Countries	Land Degradation Cost as Fraction of GDP (%)	Annual Cost of Land Degradation per Capita (US$)	Benefit-Cost Ratio of Integrated Landscape Management
Benin	8.0	58.0	4.0
Botswana	3.2	188.2	6.2
Burkina Faso	26.0	126.3	5.7
Central African Republic	40.0	166.8	3.6
Eswatini	2.9	95.9	4.0
Ethiopia	5.3	40.9	4.2
Gambia, The	9.0	42.7	8.5
Ghana	6.0	61.0	4.8
Guinea	12.0	53.8	4.1
Kenya	4.5	34.4	4.1
Lesotho	3.6	28.7	6.0
Madagascar	23.0	87.5	3.6
Malawi	6.8	18.3	3.9
Namibia	19.0	797.4	3.7
Niger	3.9	29.0	6.0
Senegal	8.4	80.8	4.5
Sierra Leone	19.0	67.0	4.8
Tanzania	13.7	40.1	3.8
Zimbabwe	6.3	31.2	3.2
Minimum	2.9	18.3	3.2
Average	11.8	107.8	4.7
Maximum	40.0	797.4	8.5
Standard deviation	10.1	173.4	1.3

Source: Global Mechanism of the UNCCD (2018) and Nkonya et al. (2016).
Note: For the indicators Land Degradation Cost as Fraction of GDP (%) and Annual Cost of Land Degradation per Capita (US$), green = low, yellow = medium, and red = high. For Benefit-Cost Ratio of Integrated Landscape Management, red = low, yellow = medium, and green = high.

Agroforestry has shown enormous promise for co-delivery of landscape restoration and climate adaptation and mitigation benefits, in addition to improving food security in Africa. It provides five main benefits: food, fuel, fertilizer, fiber, and fodder. Intercropping with leguminous trees increases yields. A significant proportion of rural households use fuelwood from trees, some of which are derived from improved fallows on their farmlands. Fertilizer trees can generate up to 200 kg of nitrogen per hectare annually, thereby reducing farmers' fertilizer expenditure. Farmers also derive timber for domestic uses from crop fields, while leguminous fodder trees can be used to improve livestock productivity. Investing in agroforestry on 25 percent of cropland (75 million ha) in Africa to increase crop yields by an average of 50 percent would produce 22 million more tons of food per year. Such a scale-up could potentially provide 285 million people with an additional 615 kcal per person per day. Savings of more than 6 million tons of inorganic fertilizer would be generated, in addition to sequestering 1 Gt CO_2e per year (World Bank 2012; WRI 2013). Other associated benefits include improved soil structure, diversified income from wood products, and increased drought resilience from increased water storage.

The choice of trees is crucial for realizing the full productivity and climate benefits of agroforestry systems. One of the most promising fertilizer tree species is *Faidherbia albida*, an acacia species native to Africa and the Middle East. *Faidherbia* is widespread throughout Africa, thrives on a range of soils, and occurs in different ecosystems ranging from dry lands to wet tropical climates. It fixes nitrogen and has the special feature of reversed leaf phenology, a characteristic that makes it dormant and shed its leaves during the early rainy season and to leaf out at the onset of the dry season. This makes *Faidherbia* compatible with food crop production because it does not compete for light, nutrients, and water. Farmers have frequently reported significant crop yield increases for maize, sorghum, millet, cotton, and groundnut when grown in proximity to *Faidherbia*. Given that it can take up to five years for *Faidherbia* and other trees in agroforestry systems to generate economic returns, farmers are turning to alternative species such as *Gliricidia sepium* that begins to yield benefits within two years of establishment. *Gliricidia* is used for many purposes, including as shade for plantation crops, live fencing, fodder, green manure, intercropping, and firewood.

5.2 IMPROVE THE EFFICIENCY OF AGRICULTURAL VALUE CHAINS USING MARKET SYSTEM APPROACHES

Throughout Africa, there exists over 200 million ha of uncultivated land that can be brought to productive use in climate-smart ways. Africa's food and agribusiness markets are expected to top US$1 trillion by 2030 (World Bank 2013a). African agriculture is also energized by entrepreneurial youth and an engaged private sector that is taking note of its potential. Young Africans are making agriculture a viable business, creating opportunities for farmers as well as themselves.

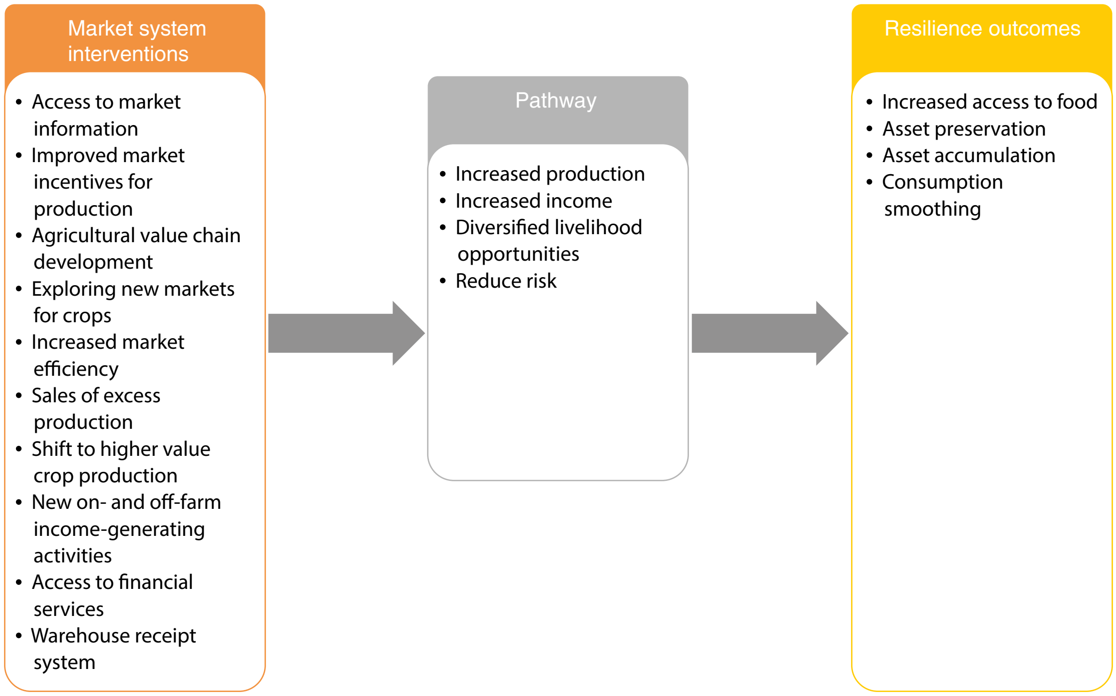
These factors present opportunities to build climate resilience for Africa's agriculture and food system through a market system approach. A market system approach seeks to connect the poor to markets and use the private sector to encourage poverty reduction and economic growth (Kuhl 2018; World Bank Group 2018b). Programs using a market systems approach focus on strengthening value chains and identifying market opportunities for the smallholder farmers. Such approaches aim to mobilize private sector resources for development, rather than relying solely on limited public sources of finance. The greatest potential for expansion lies with private finance, and the engagement of private business in the development process tends to be more sustainable than other approaches (figure 6).

Strengthening agricultural value chains is central to the use of the market system approach in building resilience through value addition, diversifying rural enterprises, and increasing household incomes. An effective approach to strengthening value chains requires (a) ensuring that financing benefits smallholder producers and supports small and medium enterprises and job creation along the value chain; (b) addressing the entire ecosystem including the business environment and support services needed to make agricultural value chains thrive; and (c) managing transaction costs and risks (World Bank Group 2018b).

Current levels of investment in agricultural value chains are insufficient to achieve key development goals, including ending poverty and hunger and boosting shared prosperity. Of the estimated US$140 billion annual investment requirement, US$50 billion, or 36 percent, is needed from the private sector in the form of on-farm and agro-processing investments. Crowding in the private sector to optimize the use of scarce public resources will be instrumental to achieving development goals in agriculture. Factors that can help maximize finance for agricultural development include improving the policy and regulatory environment for private sector participation in value chains, promoting responsible investment,[3] and using public financing to improve private incentives and reduce risks and transaction costs.

3 http://www.fao.org/3/a-au866e.pdf

FIGURE 6: Relationship between Market System Interventions and Resilience



Source: Modified from Kuhl (2018).

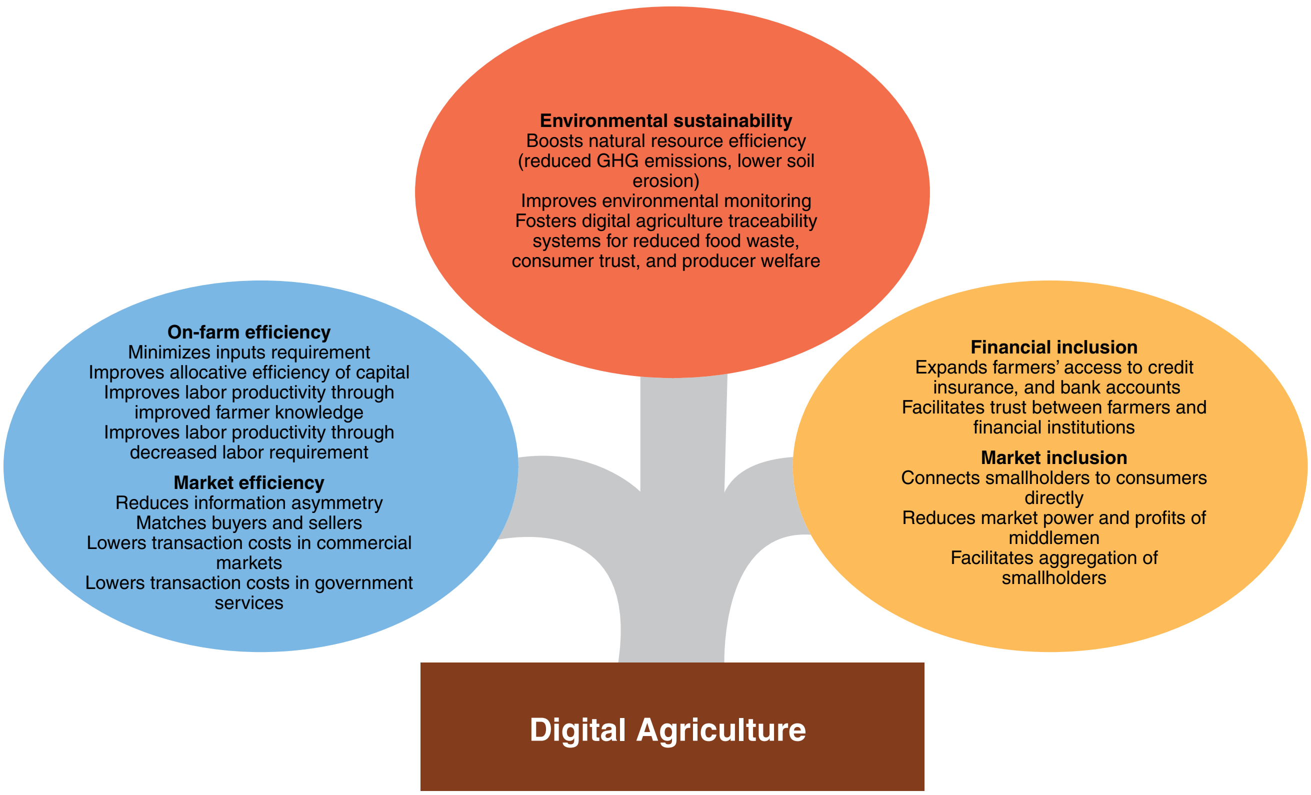
5.3 FACILITATE BROADER ADOPTION OF DIGITAL SOLUTIONS FOR THE FOOD SYSTEM

Digital technologies for collecting, storing, analyzing, and sharing information digitally, including mobile phones and the Internet, have significant potential to improve efficiency, equity, and environmental sustainability in the food system (World Bank Group 2019d). Digital agriculture influences the entire agri-food value chain—before, during, and after on-farm production (Shepherd et al. 2018). Digital agricultural technologies make it possible to collect and leverage huge amounts of critical data at minimal costs—thus making a farmer's field operations more insight driven and potentially more productive and efficient.

Examples of on-farm digital agriculture include yield mapping, GPS guidance systems, and variable rate application. Another common example of digital technologies is the dissemination of agro-weather advisories that enables access to timely, cost-effective, and personally relevant information on weather and impending disasters, for improved agronomic decision making. The application of digital technology in the design and delivery of integrated weather and market advisories using big data analytics is increasingly helping countries identify conditions that may endanger food security and inform farmers' decisions to adequately respond to and, when possible, capitalize on the changing conditions.

Another example of digital technologies application is agriculture e-commerce, a business model that provides the opportunity to streamline the agricultural value chain and reduce inefficiencies in the distribution of farm produce. Agriculture e-commerce business models offer several benefits to smallholders: increased productivity, improved incomes, reduced wastage, and financial inclusion (GSM Association 2019).[4] Other examples of digital agriculture include e-extension services, warehouse receipt systems, and blockchain-enabled food traceability systems.[5] If properly implemented, digital solutions can be potential game changers for Africa's agri-food systems. The adoption of digital agriculture can make the agricultural value chain more efficient, equitable, and environmentally sustainable (figure 7).

FIGURE 7: Benefits of Digital Agriculture



Source: Adapted from https://en.wikipedia.org/wiki/Digital_agriculture#Effects_of_digital_agriculture_adoption

Increasing the adoption of digital technologies in the food system will require addressing both the supply- and demand-side factors. The supply-side factors include rural network coverage and availability of digital applications, while the demand-side factors include skills and knowledge, trust, affordability, and complementary investments that will enable smallholders to capitalize on the benefits of digital technologies (table 9). Addressing these factors will require a range of public policy actions including increasing the space for private sector activity, improving the policy and regulatory environment, and using public financing to help crowd-in private sector investments (World Bank Group 2019d).

4 https://www.gsma.com/mobilefordevelopment/resources/e-commerce-in-agriculture-new-business-models-for-smallholders-inclusion-into-the-formal-economy/
5 https://en.wikipedia.org/wiki/Digital_agriculture

TABLE 9: Public Sector Strategies for Facilitating Broader Adoption of Digital Technologies for Improved Food System Outcomes

	Supply-side Factors		Demand-side Factors
MFD Cascade of Questions	**Expand Rural Network Coverage (expand digital infrastructure)**	**Develop Relevant Digital Applications (foster digital entrepreneurship)**	**Facilitate Demand for Digital Technologies in the Food System (particularly smallholder farmers)**
Is the private sector doing it?	• >90% coverage in high-income countries • 50% coverage in low-income countries (even lower for 3G or faster networks)	• Increase in ag-tech investment over last 10 years; growth in ag-tech start-ups in Africa over the past two years • Significant variation across countries	• Higher farmer adoption of digital technologies in high-income countries relative to low-income countries; and higher adoption rates on larger farms
If not, then is it because of limited space for private sector activity?	• Foster competition among telecoms (competition is associated with more extensive rural coverage)	• Lower entry costs to facilitate competition among digital platforms	

If not, then is it because of policy and regulatory gaps and weaknesses?	• To help lower the cost of providing rural coverage
	  • Adopt a spectrum policy that boosts connectivity
	  • Lower infrastructure taxes/duties
	  • Allow infrastructure sharing
	  • Ensure consistency/streamline local-level regulations
	  • Reduce policy/regulatory uncertainty
		• Improve the enabling environment for business development
		• Design digital regulations around functionality
		• Clarify data ownership
		• Develop governance arrangements for open data
		• Invest in open data that have public good characteristics
			• Improve farmers' incentives to invest
			• Develop data governance arrangements that build users' confidence and trust in digital technologies

If not, then can public investment help crowd in private investment?	• Invest in complementary infrastructure • As a last resort, subsidize service providers to offset higher costs of rolling out rural coverage	• Support skills development • Improve access to finance for start-up and early maturity ag-tech enterprises • Support increased use of digital payments	• Support skills development for vulnerable groups • Develop relevant, customized tools • Reduce costs of technology adoption • Improve access to finance • Invest in complementary infrastructure
		• Support development of digital farmer identification	

Source: World Bank Group 2019d.
Note: MFD = Maximizing Finance for Development.



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