Scaling Up Climate-Smart Agriculture through the Africa Climate Business Plan




WORLD BANK GROUP

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Preface

Scaling up climate-smart agriculture in Africa is vital to ending hunger and boosting shared prosperity on the continent. The Africa Climate Business Plan (ACBP) launched at the twenty-first Conference of Parties (COP21) in Paris is an important step toward addressing the interlinked challenges of food security and climate change. The ACBP calls for focused public and private sector investments to help African people and countries adapt to climate change and build up the continent's resilience to climate shocks. The Plan includes a focus on climate-smart agriculture and supports the vision for accelerated agricultural transformation in support of the Malabo Declaration.

This report documents World Bank support to African governments in making climate-smart agriculture a priority. From January 2016 to April 2018, the World Bank's Board of Directors approved 83 projects supporting climate-smart agriculture in Africa with cumulative investments of US$3.8 billion. Spreading across 30 countries, the projects aim to improve the livelihoods of about 5 million farmers and increase the climate resilience and productivity of about 3 million hectares of land.

Based on a review of this portfolio, the report finds that 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 climate-smart agriculture portfolio, followed by improved water management, conservation agriculture, agroforestry, and, notably, digital agriculture. Why digital? The application of digital technology in the design and delivery of integrated weather and market advisories using big data analytics is increasingly helping countries to identify conditions that may endanger food security and inform farmers' decisions to adequately respond to, and when possible, capitalize on the changing conditions.

This report also highlights the need to urgently step up knowledge sharing, learning, and capacity enhancement for climate-smart agriculture policies, technologies, and practices in Africa. It recommends developing country-specific climate-smart agriculture projects and crowding in investment by increasing the space for private sector activity in agricultural value chains. It is hoped that these measures will help increase the resilience of Africa's agricultural system to climatic shocks, in addition to ushering in a sustainable agricultural transformation that benefits all.

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2. **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 integrated approach that aims to address the interlinked challenges of food security and climate change by sustainably increasing agricultural productivity to support equitable increases in farm incomes, food security, and development; adapting and building resilience of agricultural and food systems to climate change at multiple levels; and reducing greenhouse gas (GHG) emissions from agriculture.

> *Climate change and food insecurity are the twin development challenges that may define Africa's future.*

Policy frameworks for CSA implementation

3. **The assessment of the progress in implementing CSA under the ACBP was carried out against the background of the extent to which African countries have adopted CSA policies and created the enabling environment for implementation.** The set of CSA policy indicators developed by the World Bank assesses the enabling environment, that is policy and institutional frameworks, readiness mechanism, services and infrastructure, and coordination mechanism within a country supporting the implementation of CSA.

4. **African countries scored low on the CSA Policy Indicators, especially *Readiness Mechanism*, *Services and Infrastructure*, and the *Aggregated Policy Index*.** This indicates that they face critical challenges related to leveraging investments for climate action, promoting adoption of new technologies, providing enabling services, and creating the necessary institutions for CSA implementation. A key contribution to the low *Readiness Mechanism* scores is the lack of monitoring and implementation systems to support adaptation and mitigation policies in many African countries. The low average score of the *Services and Infrastructure* results from the inadequacy of critical CSA enablers—such as well-functioning agricultural extension system, poor access to input and output markets, inefficient agricultural risk management system, and scarce social safety nets—that are critical for promoting the adoption of CSA.

> *African countries face critical challenges related to leveraging investments for climate action, promoting adoption of new technologies, and creating the necessary institutions for CSA implementation.*

5. **South Africa with its strong agricultural export markets is a top performer (Aggregated Policy Index of 77 percent) because its agricultural sector is supported by market information systems, agriculture crop insurance, warehouse receipts systems, and early warning systems (EWSs) for weather and pest management that are critical for well-functioning markets.** The country also is able to leverage investments for the adoption of new technologies through significant public investments in research and development (R&D). Tanzania's relatively

high score (Aggregated Policy Index of 76 percent) is driven, among others, by strong coordination mechanisms. Tanzania's commitment to addressing climate adaptation and mitigation in the agriculture sector is reflected in the country's National Climate Change Strategy. A multi-sectorial approach facilitated by the National Climate Change Technical Committee (NCCTC) and National Climate Change Steering Committee (NCCSC) is used to support CSA. Rwanda is another top performer (Aggregated Policy Index of 73 percent) with a dedicated Strategic Program for Climate Resilience (SPCR). The country also has established public-private partnerships to develop services and infrastructure, such as crop insurance for CSA. Compared to others, Rwanda scores high in agricultural adaptation policy, agricultural mitigation policy, agricultural R&D, social safety nets, national GHG inventory system, and disaster risk management coordination.

6. **The bottom performers on the CSA Policy Index in Africa include Sudan (with Aggregated Policy Index of 31 percent), Central African Republic (36 percent), and Equatorial Guinea (37 percent).** The countries are among the top five oil-producing countries in the region with economies heavily dependent on oil revenues and the agricultural sector critically underdeveloped. Most of the low performers have poorly developed or no National Adaptation Plan of Actions (NAPAs), for example, to support CSA implementation. The lack of diversification in the economy and underdevelopment of the agriculture sector has accounted for weak institutional mechanism and enabling environment for CSA. Sudan, however, is taking steps to create a stronger enabling environment. For example, through the Agricultural Revival Program (ARP) launched in 2008, the country aims to address structural weaknesses in the sector, and many of the priority areas of intervention coincide with the NAPA objectives. Also, there are some services in place with the potential to create a strong enabling environment for CSA, such as the Sudanese Food and Agriculture Market Information System, which collects and disseminates crop, livestock, and horticultural and animal products prices to market participants. Sustained commitment to improved agricultural policies, consistent approach, and better coordination is essential to develop a transformational agenda for agriculture in Sudan.

Adoption of CSA technologies and practices

7. **From January 2016 to April 2018, the World Bank's Board of Directors approved 83 projects supporting climate-smart agriculture in Africa with cumulative investments of US$3.8 billion.** Spreading across 30 countries, the projects aim to improve the livelihoods of about 5 million farmers and increase the climate resilience and productivity of about 3 million hectares of land.

8. **Countries adopt a range of context-specific climate-smart technologies and practices to meet their climate change and food security goals.** Improved livestock production is the most prevalent in 63 percent of the CSA projects portfolio, followed by improved water management (57 percent), conservation agriculture (CA; 53 percent), agroforestry (47 percent), and digital agriculture (39 percent). Livestock production systems are vital for reducing rural poverty in Africa. It is a major economic sector contributing an average of 40 percent of the continent's agriculture gross domestic product (GDP). The sector also is critical for food and nutrition security; animal source foods are protein dense and contain key micronutrients not found in plant-based foods. Improved livestock management focuses on four key elements: improved feed and nutrition; animal breeding and health care; sustainable land management, such as silvopastoral practices, a land use system that integrates trees and shrubs into pastures, and rotational grazing of livestock; and integrated manure management.

"Countries adopt a range of context-specific climate-smart technologies and practices to meet their climate change and food security goals.

9. **Complementary to the expanding investments in improved livestock production is the implementation of the Program for Climate-Smart Livestock (PCSL) in Africa through a joint World Bank-German initiative.** The Program aims at fostering climate-smart livestock management practices, developing monitoring systems and policies, and providing guidance for up-scaling climate-smart livestock practices across the continent. The initiative will assist governments in fulfilling their commitments to achieve climate change adaptation and mitigation goals, and ultimately to attract further national and international investment for CSA, in general.

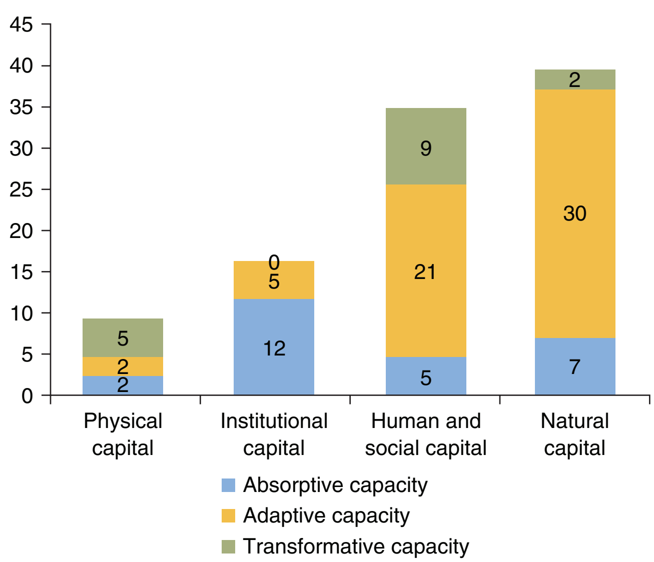
10. **Agroforestry, an integrated land-use system combining trees and shrubs with crops and livestock is one of the most conspicuous land use systems across landscapes and agroecological zones in Africa.** Some 1.5 billion hectares are suitable for some type of agroforestry in the continent. Agroforestry has shown enormous promise for co-delivery of climate adaptation and mitigation benefits, in addition to improving food security in Africa. Investing in agroforestry on 25 percent of cropland (75 million ha) of land 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 kilocalories (kcal) per person per day. Savings of more than 6 million tons of inorganic fertilizer would be generated, in addition to sequestering 1 gigaton (Gt) of carbon dioxide equivalent per year.

11. **New digital technologies make it possible to collect and leverage huge amounts of critical data at minimal costs—thus making a farm's field operations more insight-driven and potentially more productive and efficient.** A major application of digital agriculture is in the design and delivery of integrated weather and market advisories using big data analytics. This helps inform farmers' decisions about what to grow, when to plant and harvest, how to allocate their labor, and where to sell their produce. The resulting combined data is analyzed and interpreted so that the farmer can make more informed and personally relevant decisions, leading to increased yields and resilience. Application of digital agriculture leads to more efficient input use matched to climatic trends and reduced GHG emissions.

> *Application of digital technologies leads to more efficient input use and reduced agricultural emissions.*

12. **Despite increasing frequency of weather-related risks, most smallholder farmers in Africa rarely have access to crop insurance due to large informational asymmetries and the high transaction costs of dealing with smallholder farmers.** Farmers often rely on informal approaches to risk management, such as accumulating precautionary savings, planting lower-value crops that are less sensitive to weather fluctuations, and diversifying their sources of income away from the most profitable options. Innovations in insurance markets, such as the index-based insurance that links indemnity payments to easily observed outcomes—such as rainfall—instead of to individual farmer yields, have the potential to address these problems by helping farmers' smooth incomes in bad years and helping governments and relief agencies respond quickly and fully to weather-related disasters when they occur.

FIGURE ES.1: DISTRIBUTION OF CSA PROJECT ACTIVITIES ACROSS TYPES OF CAPITAL AND CAPACITIES STRENGTHENED (%)



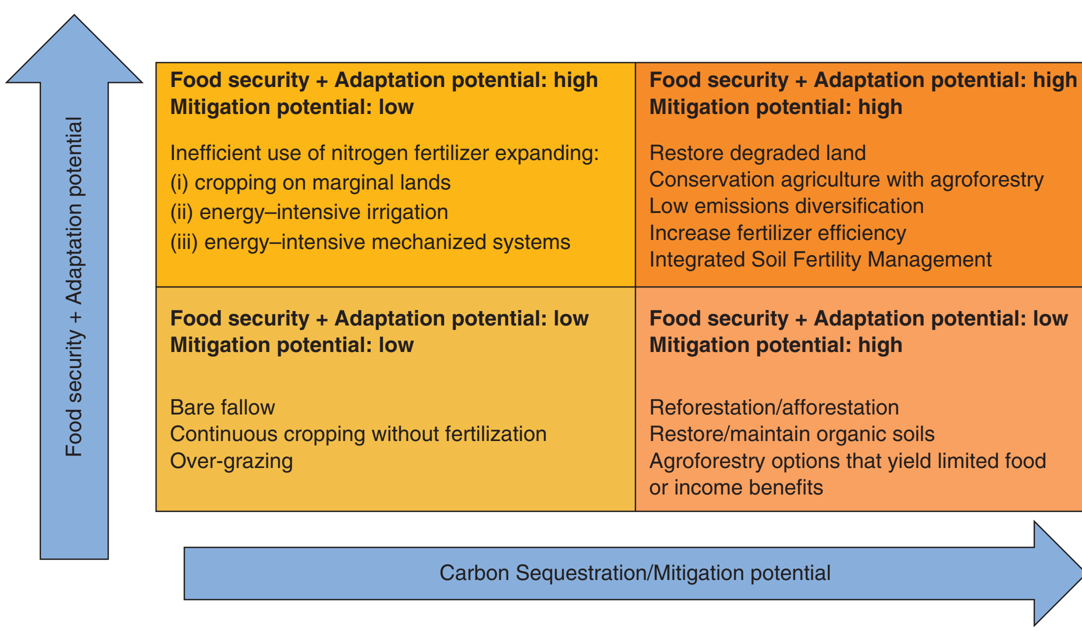
Barriers to adoption of CSA technologies and practices

13. **The adoption of CSA practices can face a variety of socioeconomic and institutional barriers.** These include the need for significant upfront expenditures on the part of poorer farmers, the non-availability of some inputs in the local markets, lack of information about the potential of improved techniques, and often limited capacity to implement the techniques. Certain techniques associated with sustainable land management can be incompatible with traditional practices. In some instances, the diffusion of new technologies relies on a level of social capital and experience with collective action that farmers simply do not yet have. The World Bank CSA investment projects assist in overcoming the adoption constraints by providing support for specific material inputs, linking farmers to markets, technical assistance (TA) for design and delivery of critical interventions, such as biogas energy development, and training and skills development for knowledge-intensive technologies, and strengthening local institutions to catalyze adoption.

14. **Trade-offs are inherent in the attempt to achieve the triple win of food security, resilience and mitigation.** There is the need for policy makers and resource managers to manage trade-offs across space, time, and sectors. The multiple services provided by land interact in complex ways, leading to positive and negative impacts as the production of one ecosystem service increases. Synergy results when the production of more of an ecosystem service leads to more of another, whereas trade-off—the more frequent outcome—occurs when the production of one ecosystem service decreases the supply of another. Working at the landscape level is useful for addressing food security and rural livelihood issues and in responding to the impacts of climate change and contributing to its mitigation. The landscape approach provides a framework for the better management of ecosystem services, such as agricultural productivity, carbon storage, fresh water cycling, biodiversity protection, and pollination. It allows trade-offs to be explicitly quantified and addressed through negotiated solutions among various stakeholders.

> *"The landscape approach is useful for managing trade-offs and capturing synergies between CSA pillars.*

FIGURE ES.2: TRADE-OFFS BETWEEN CSA PILLARS



Source: Modified from World Bank (2016a)

Developing resilience capacity through CSA

15. **A major goal of the ACBP is to deliver on CSA at scale to increase the efficiency and resilience of food systems in Africa.** This report also examines how African countries are building resilience to climate change through CSA. 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 (58 percent of project activities). 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 16 percent.

16. **In terms of livelihood capital, the project activities focus mainly on building natural capital (39 percent), followed by human and social capital (35 percent), institutional capital (17 percent) and physical capital (9 percent).** Soils and vegetation (natural capital) are the basic resource and the central elements of most CSA approaches. Interventions such as Integrated Soil Fertility Management (ISFM), agroforestry, and CA have the major goal of building natural capital by increasing soil health and reducing land degradation. Efforts to build human

There is a need to invest more in institutional capital through policy development and enhanced private sector participation.

capital through training and skills development will help address 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.

17. **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. 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.

> *More effort is needed to promote market system interventions to build resilience to climate change.*

18. **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 needs to also include more transformational responses to support deep, systemic, and sustainable change with the potential for large-scale impact across Africa.

> *Given the intensity, frequency, and pace of climate change and the extreme vulnerability of African agriculture, resilience building needs to also include more transformational responses.*

Recommendations

19. **Two sets of recommendations are important to further enhance the efforts to scale up CSA for transformational change in Africa.**

    1) **Provide TA and capacity development for climate-smart investment.** Large-scale systematic investment is needed for CSA to be scaled out, but there is still the need for substantial TA in some countries to develop programs that attract direct co-financing from governments, development agencies, and the private sector. The following five key TA activities have been identified for the transformative scaling up of CSA in Africa:

        (i) Develop CSA country profiles to identify entry points for investing in CSA at scale.

        (ii) Develop CSA investment plans for prioritizing CSA strategies, policies, and investments.

        (iii) Strengthen Measuring, Reporting, and Verification (MRV) systems for Nationally Determined Contribution (NDC).

        (iv) Build capacity to access climate finance.

        (v) Promote knowledge sharing, learning, and capacity enhancement for CSA policies, technologies, and practices.

    2) **Accelerate the scaling up of CSA technologies and practices.** There is a need for scaling up and replicating effective approaches and innovations to deliver productivity and climate benefits at a much bigger scale and

intensity. Agriculture needs to be transformed by shifting the food system onto a climate-smart pathway. This shift will transform the entire food system, with major impacts throughout the entire value chain. Three essential activities to support the scaling up are indicated below:

(i) Leverage the big data and geospatial capabilities tools, such as the World Bank's Agricultural Intelligence Observatory (Ag Observatory), in targeting climate-smart interventions in existing and pipeline projects.

(ii) Develop country-specific CSA projects using criteria, such as climate vulnerability, the number of rural poor, poverty rates, and prevalence of undernourishment. This will help identify countries in which the potential for accelerating agricultural transformation is huge.

(iii) Crowd in investment by increasing the space for private sector activity in agricultural markets, improving policy and regulatory environment and support services needed for successful agricultural value chains, leveraging public finance to improve private incentives, and managing private investment risks.

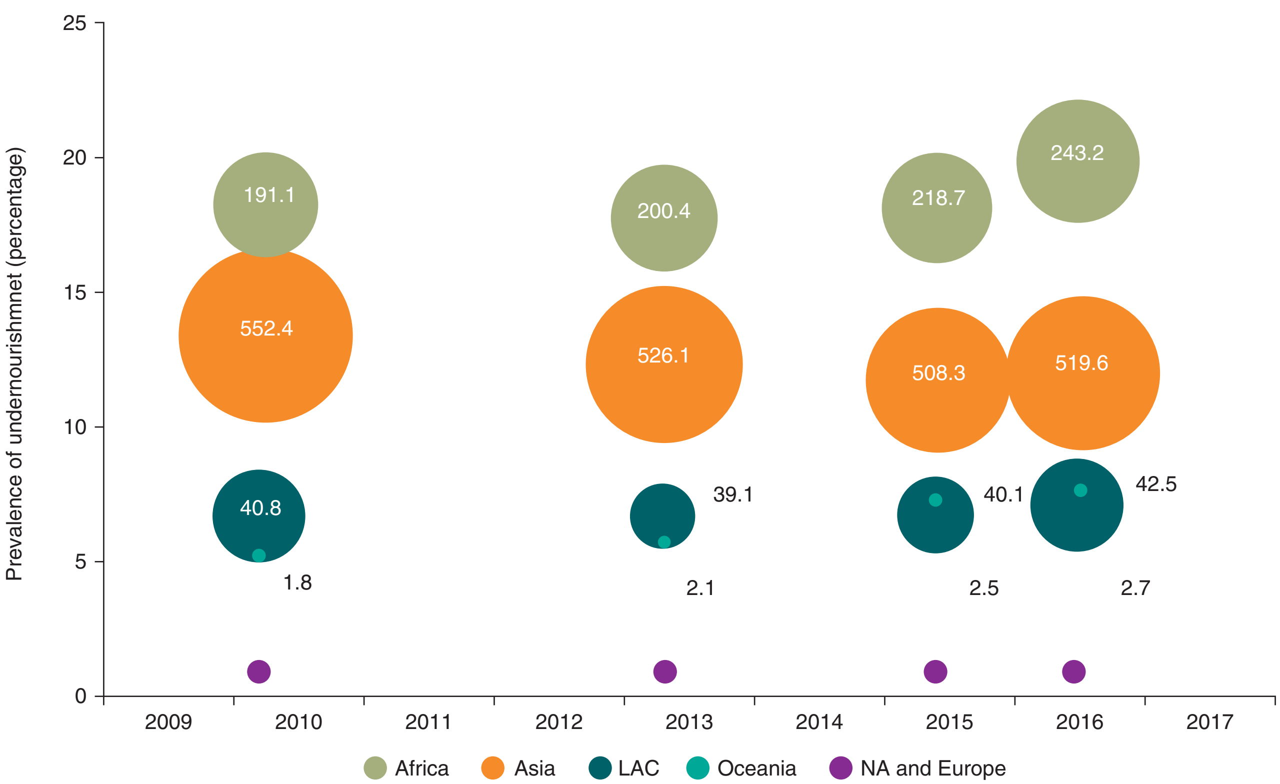
I.

Introduction

20. **Climate change and food insecurity are the twin development challenges that may define Africa's future.** More than 240 million, or one in five, people are undernourished in the continent due to lack of sufficient or nutritious food (figure 1.1). 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 2013a). 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.

21. **African agriculture is highly vulnerable to climate risks, but it also is a source of greenhouse gas (GHG) emissions.** Increased agricultural production in Africa has occurred mainly through the expansion of agricultural lands rather than through intensification, and agriculture and the associated land-use change account for 65 percent of Africa's total GHG emissions.

FIGURE 1.1: PREVALENCE AND ABSOLUTE NUMBER OF UNDERNOURISHMENT ACROSS WORLD REGIONS



Note: LAC = Latin American countries; NA = North America. The prevalence of undernourishment is higher in Africa. The absolute number of undernourished people is highest in Asia. The size of circles represents the number of undernourished people in millions as labeled.

Source: The Food and Agriculture Organization (of the UN) (FAO)

Emissions from agriculture are likely to grow due to increase in demand for food associated with growing population and urbanization.

22. **Food production in Sub-Saharan Africa needs to increase by 60 percent over the next 15 years to meet demand.** Feeding Africa nutritiously and sustainably will require a more sustainable and climate-smart food system. Without major investments in agriculture, the average African would have access to 21 percent fewer calories and climate change would increase the number of malnourished children by 10 million. If unaddressed, climate change will erode Africa's hard-won development achievements and jeopardize the prospects for further growth and poverty reduction.

23. **Fortunately, African agriculture is well positioned for transformational change.** Throughout Africa, there are more than 200 million ha of uncultivated land that can be brought to productive use. Africa uses only 2 percent of its renewable water sources. Africa's food and beverage markets are expected to top US$1 trillion in value by 2030 (World Bank 2013b). More than a dozen agribusiness investment funds have set their sights on Africa. African agriculture also is 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.

24. **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 to address Africa's intricately linked climate and development agendas.**[1] The ACBP calls for US$19 billion in funding to help African people and countries adapt to climate change and build up the continent's resilience to climate shocks (World Bank 2015).[2] The ACBP includes a focus on climate-smart agriculture (CSA) and supports the vision for accelerated agricultural transformation of the Malabo Declaration.[3] CSA is an integrated approach that aims to address the interlinked challenges of food security and climate change by sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security, and development; adapting and building resilience of agricultural and food systems to climate change at multiple levels; and reducing GHG emissions from agriculture. In collaboration with partners, the World Bank is working toward achieving the following targets in Africa by 2026: adoption of CSA by 25 million farmers, establishment of CSA on 3 million ha of farmland, creation of improved pastoral systems in at least 15 countries, and improved capacity to implement CSA policies in at least 20 countries.

25. **This report assesses policy framework for CSA implementation and progress in CSA technology adoption for Africa.** It also highlights opportunities for scaling up of CSA in the region. Chapter 2 reviews the extent to which countries have adopted policies and created the enabling environment for CSA implementation in Africa. Chapter 3 assesses resource mobilization for World Bank CSA investments and finance flows for agricultural adaptation and mitigation under the investments. It also assesses the extent to which the World Bank CSA portfolio aligns with Nationally Determined Contribution (NDC) commitments.[4] Chapter 4 assesses the extent of adoption of CSA technologies by World Bank client countries in Africa. Information is provided on the adaptation and mitigation benefits of the CSA technologies, as well as implantation challenges. Chapter 5 discusses how the technologies contribute to efficiency and resilience of food systems in Africa, while Chapter 6 concludes with opportunities for future engagement with countries in Africa. The report will benefit World Bank teams, development partners, and country clients working to promote CSA policies and practices that enable farmers to increase productivity and production sustainably, while increasing the farmers' capacity to contribute to climate change adaptation and mitigation.

[1] The ACBP is consistent with the World Bank's Climate Change Action Plan (CCAP) (https://www.openknowledge.worldbank.org/handle/10986/24451) that focuses, among other goals, on working with countries to deliver CSA that achieves the triple win of increased productivity, enhanced resilience, and reduced emissions. The CCAP emphasizes impact at scale and improving the resilience of the global food system.

[2] Resource mobilization target for CSA is US$3 billion by June 2020, end of International Development Association (IDA) 18.

[3] Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. https://au.int/sites/default/files/documents/31006-doc-malabo_declaration_2014_11_26-.pdf.

[4] Nationally Determined Contribution (NDC) is a statement of a country's current emissions, reduction targets, and adaptation priorities that is used to prioritize climate actions and transition to low emission development pathways.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II.

Policy Frameworks for CSA Implementation in Africa

26. **The World Bank's CSA Policy Index framework was used to assess a country's enabling environment for implementing CSA (World Bank 2017a).** The framework comprises indicators that capture the readiness of national governments, the effectiveness of institutions, and the availability of the enabling mechanisms to implement CSA. The Policy Index reflects three themes:

    1) **Readiness mechanism.** This refers to the capacity of countries to plan and deliver adaptation and mitigation programs in ways that are catalytic and fully integrated with national agricultural development priorities. It also measures the country's capacity to leverage investments for climate action and incentivize adoption of new technologies.

    2) **Services and infrastructure.** This measures the country's institutional capacity to mainstream CSA based on the availability and functioning of services and enablers of CSA implementation.

    3) **Coordination mechanism.** This assesses the country's ability to mobilize and coordinate across various ministries, institutions, and stakeholders to support CSA.

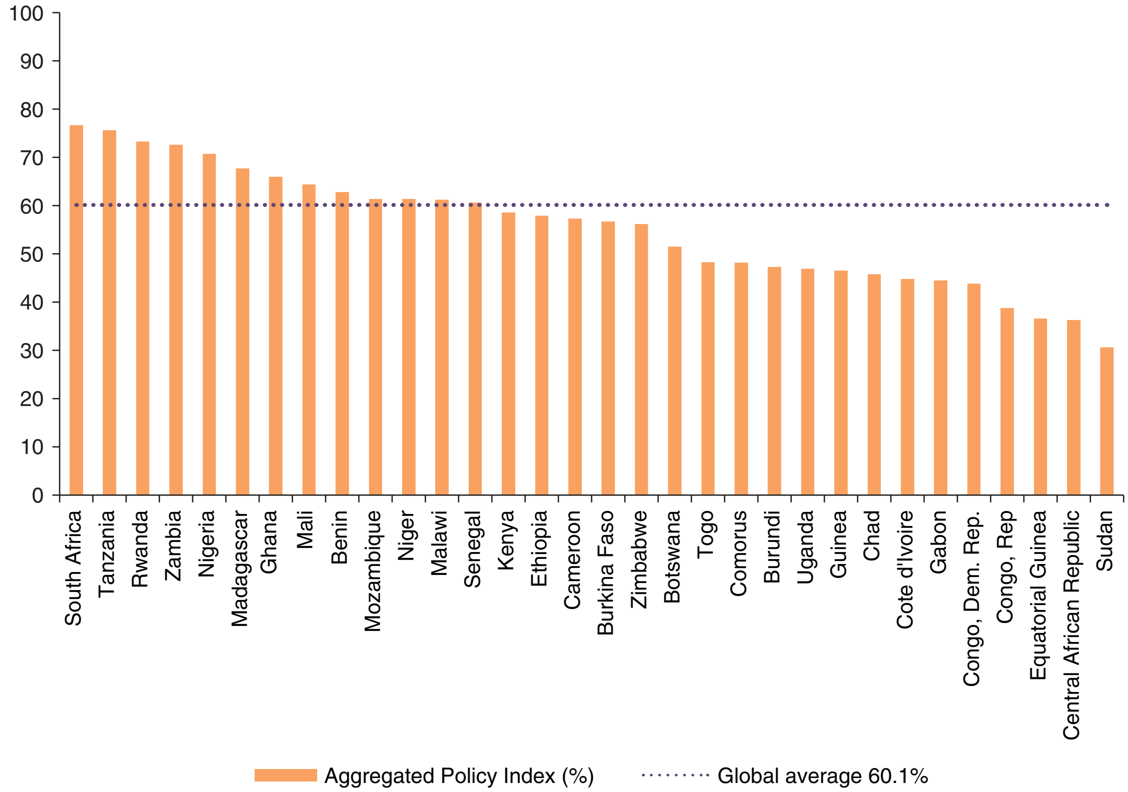
27. **Table 2.1 shows that Sub-Saharan African countries scored low on the CSA Policy Indicators, especially *Readiness Mechanism, Services and Infrastructure*, and the *Aggregated Policy Index*.** A key contribution to the low *Readiness Mechanism* scores is the lack of monitoring and implementation systems to support adaptation and mitigation policies in many African countries. The low average score of the *Services and Infrastructure* is because of the inadequacy of critical CSA enablers, such as well-functioning agricultural extension system, poor access to input and output markets, inefficient agricultural risk management system, and scarce social safety nets that are critical for promoting the adoption of CSA. The *Coordination Mechanism* average score is just about the average global score and still indicates a need to build robust institutions for CSA implementation.

28. **Figure 2.1** indicates that only 13 out of 32 Sub-Saharan African countries (41 percent) scored above the global average *Aggregated Policy Index*. South Africa—with its strong agricultural export markets—is a top performer (Aggregated Policy Index of 77 percent) because its agricultural sector is supported by market information systems, agriculture crop insurance, warehouse receipts systems, and early warning systems (EWSs) for weather and pest management that are critical for well-functioning markets. The country also is able to leverage

TABLE 2.1: COMPARISON OF POLICY INDICATOR SCORES FOR SUB-SAHARAN AFRICA WITH THE GLOBAL AVERAGES

	Sub-Saharan Africa average score (%)	Global average (%)	Proportion of Sub-Saharan African countries scoring below global average (%)
Readiness Mechanism	49.6	53.8	59
Services and Infrastructure	55.8	62.4	63
Coordination Mechanism	67.8	67.3	34
Aggregated Policy Index	55.3	60.1	59

FIGURE 2.1: CSA POLICY INDEX FOR 32 SUB-SAHARAN AFRICAN COUNTRIES



Source: World Bank (2017a)

investments for the adoption of new technologies through significant public investments in research and development (R&D).

29. **Tanzania's relatively high score (Aggregated Policy Index of 76 percent) is driven primarily by its relatively high scores in services and infrastructure and coordination mechanisms.** Tanzania's commitment to addressing climate adaptation and mitigation in the agriculture sector is reflected in the country's NAPA and National Climate Change Strategy. Beyond these two plans, the National Strategy for Growth and Reduction of Poverty (NSGRP II) also incorporates climate change as a crosscutting issue. A multi-sectorial approach facilitated by the National Climate Change Technical Committee (NCCTC) and National Climate Change Steering Committee (NCCSC) is used to support CSA.

30. **Rwanda with an Aggregated Policy Index of 73 percent is another top performer.** Rwanda's commitment to CSA is reflected in the National Strategy for Climate Change and Low Carbon Development. The strategy includes a monitoring framework for its mitigation and adaptation programs and involves various ministries including the Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Infrastructure (MININFRA), and Municipal Authorities in its implementation. The country's Strategic Program for Climate Resilience (SPCR) developed through a multi-stakeholder process focuses on agricultural resilience, sustainable landscapes, and strengthening institutional capacity among others. The country also has established several public-private partnerships to develop services and infrastructure, such as crop insurance, that have the potential to create a strong enabling environment for CSA. Compared to others, Rwanda scored high in agricultural adaptation policy, agricultural mitigation policy, agricultural R&D, social safety nets, national GHG inventory system, and disaster risk management coordination.

31. **The bottom performers on the CSA Policy Index include Sudan (with Aggregated Policy Index of 31 percent), Central African Republic (36 percent),**

and Equatorial Guinea (37 percent). The countries are among the top five oil producing countries in the region with economies heavily dependent on oil revenues, and the agricultural sector critically underdeveloped. Most of the low performers have poorly developed or no NAPAs, for example, to support CSA implementation. The lack of diversification in the economy and underdevelopment of the agriculture sector has accounted for weak institutional mechanism and enabling environment for CSA.

32. **Sudan has expressed commitment to addressing adaptation to climate change through its NAPA; however, there are no well-defined strategies to address this goal.** The country also lacks sufficient services and infrastructure to support adaptation strategies in the agriculture sector. The county is, however, taking steps to create a stronger enabling environment. For example, through the Agricultural Revival Program (ARP) launched in 2008, the country aims to address structural weaknesses in the sector and many of the priority areas of intervention coincide with the NAPA objectives. There also are some services in place with the potential to create a strong enabling environment for CSA, such as the Sudanese Food and Agriculture Market Information System, which collects and disseminates crop, livestock, and horticultural and animal products prices to market participants on a weekly basis. Sudan scored exceptionally low in agricultural mitigation policy, rural access index, and social safety nets. A recent study underscores the need for sustained commitment to improved agricultural policies and better coordination to develop a transformational agenda for agriculture in Sudan (World Bank, 2016c).

33. **Commitment from the government—demonstrated through national climate change policies and strategies—also is important for creating an enabling environment for CSA.** For example, Madagascar with an *Aggregated Policy Index* score of 68 percent has built strong institutional frameworks through regional arrangements supported by the Indian Ocean Islands to integrate adaptation strategies and disaster risk response to climate change in national policies and strategies. Some 59 percent of the Sub-Saharan African countries in the sample scored below the global average *Aggregated Policy Index*. This reveals critical challenges related to leveraging investments for climate action, promoting adoption of new technologies, providing enabling services, and creating the necessary institutions for CSA implementation. Addressing these gaps is one of the central focuses of the ACBP. The ACBP supports the adoption of evidence-based policies and institutional strengthening for CSA. Progresses in these areas are discussed in this report.

III.

Resource Mobilization for CSA

34. **This chapter provides information on resource mobilization for the CSA investments and finance flow for agricultural adaptation and mitigation.** It also assesses the alignment of the World Bank's CSA portfolio to Agricultural Nationally Determined Contributions (Ag-NDCs) priorities and actions. The chapter provides an indication of areas where countries may require further assistance in meeting their NDC goals.

3.1 Data on CSA investment and climate co-benefits

35. **The ACBP aims to build a pipeline of innovative and transformational projects to tackle climate change and establish a platform to mobilize investments, thereby contributing to filling the climate financing gap in the region.** Table 3.1 provides data on the implementation of the CSA component of the ACBP. From January 2016 to April 2018, the World Bank's Board approved 83 projects supporting CSA with cumulative commitments of US$3.8 billion. The projects are spread across 30 countries in Africa (figure 3.1). These projects aim to improve the livelihoods of about 5 million farmers and increase the climate resilience and productivity of about 3 million ha of land.

36. **An agricultural activity provides climate co-benefits if it promotes mitigation or adaptation.** It promotes agricultural mitigation through efforts to reduce or avoid GHG emissions and/or enhance carbon sequestration. The activity fosters adaptation if it reduces the vulnerability of people or the agricultural system to the impacts of climate change and risks related to climate variability, by

TABLE 3.1: STATUS OF AGRICULTURE COMPONENT OF THE ACBP PORTFOLIO[5]

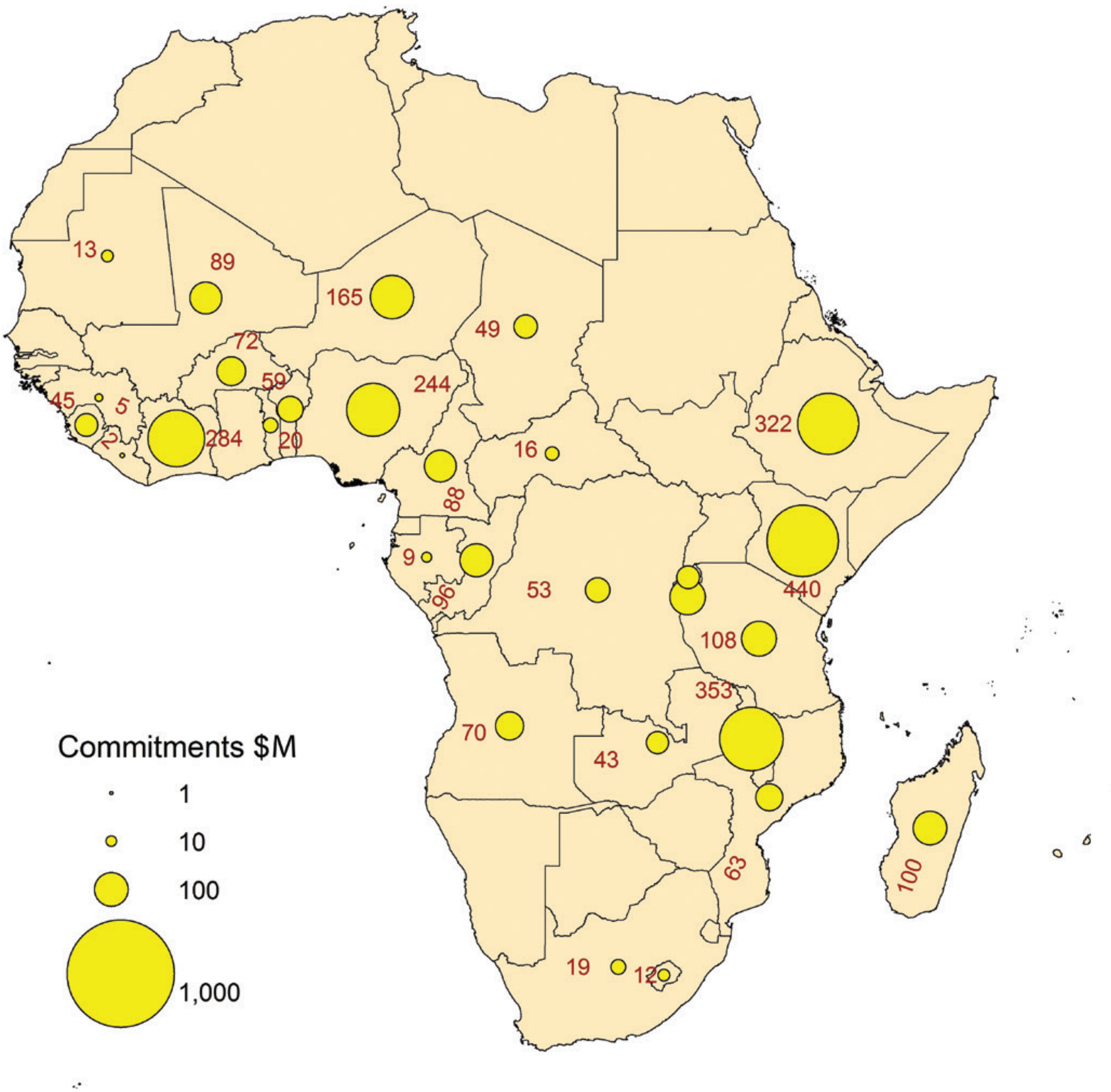
Period	All IBRD/IDA projects with agriculture sector components		Of which, projects with climate co-benefits					
	No.	Commitment USD $M	No.	Total co-benefits USD $M	(i) adaptation USD $M	(ii) mitigation USD $M	Farmers reached with CSA[6]	Land area (ha) are under CSA[7]
Jan 16 – Sep 16	17	821	11	435	238	197	1,211,400	558,382
Oct 16 – Sep 17	48	1,925	31	756	538	218	3,104,787	2,353,328
Oct 17 – Apr 18	18	1,054	7	354	246	108	651,800	18,661
Total	**83**	**3,800**	**49**	**1,546**	**1,022**	**524**	**4,967,987**	**2,930,371**

Note: ha = hectares; IBRD/IDA = International Bank for Reconstruction and Development/International Development Association.

[5] Co-benefits assessment for projects from October 2017 is provisional and is subject to change until Board approval.
[6] Calculated as farmers reached with agriculture assets or farmers adopting improved agriculture practices.
[7] Calculated as area reforested or with increased tree cover plus land area under sustainable landscape management practices multiplied by a "CSA ratio" plus area provided with new/improved irrigation or drainage services multiplied by a "CSA ratio".

maintaining or increasing adaptive capacity and resilience.[8] Total climate co-benefits from January 2016 to April 2018 were about US$1.5 billion, with 66 percent of the finance flowing into adaptation. Higher finance flows to adaptation compared to mitigation reflect the priorities of African countries to address the sector's climate vulnerability and increase resilience. However, given the vast potential

FIGURE 3.1: WORLD BANK TOTAL COMMITMENTS FOR AGRICULTURE JANUARY 2016–APRIL 2018[9]



Source: Authors

[8] The World Bank tracks the climate mitigation and adaptation co-benefits of all the projects it finances using the Multilateral Development Banks' Joint Methodology for Tracking Climate Finance. (http://www.adb.org/documents/joint-report-mdbs-climate-finance-2015). The World Bank is committed to increasing the share of International Development Association (IDA) and International Bank for Reconstruction and Development (IBRD) financing with climate co-benefits to 28 percent by 2020.

[9] Fourteen regional projects spanning several countries are not reflected in the figure.

for African agriculture to reduce emissions through climate-smart practices, the mitigation flows should expand considerably in the future.

37. **Capturing adaptation finance co-benefits requires the project documents to**

- Establish vulnerability of the agricultural system to climate variability in the context of the climate risk screening completed at the Project Concept Note stage;
- Provide an intent that the project will address these vulnerabilities; and
- Allocate bank financing to the activities under the various project components.

38. **For proper assessment of mitigation finance co-benefits, the project team needs to make an effort to assign financing to those specific activities that have been included in the ex-ante GHG evaluation of the project.**

39. **Climate co-benefits are an essential component of the finance used by countries to support their mitigation and adaptation actions.** They should, therefore, be tracked and reported through their NDC Measuring, Reporting, and Verification (MRV) system. It would be useful to promote client ownership of the co-benefits assessment during project preparation so that countries could better understand how the World Bank engagement has helped them in meeting their climate change goals.

3.2 Contributions to NDC implementation

40. **Under the Paris Agreement, countries submit an NDC document that outlines their commitment to reduce GHG emissions and strengthen resilience to climate change.** The NDC, a statement of a country's current emissions, reduction targets, and adaptation priorities, provides an important baseline for prioritizing climate actions. It offers opportunities to better understand client countries' plans and priorities for addressing climate change. At the same time, it helps identify the kind of support that the client countries may require toward implementing the plans and transitioning to low emission development pathways.

41. **To assess the extent to which the ACBP contributes to and supports the implementation of Sub-Saharan Africa's NDCs, projects were assessed to determine the alignment of development objectives and project components with NDCs goals and targets.** ACBP projects with target sectors (or sub-sectors) articulated as priority areas in the country NDCs are considered as contributing to the implementation of the NDCs. The analysis was carried out at both the country and the regional levels and focused on countries where the ACBP projects are present.

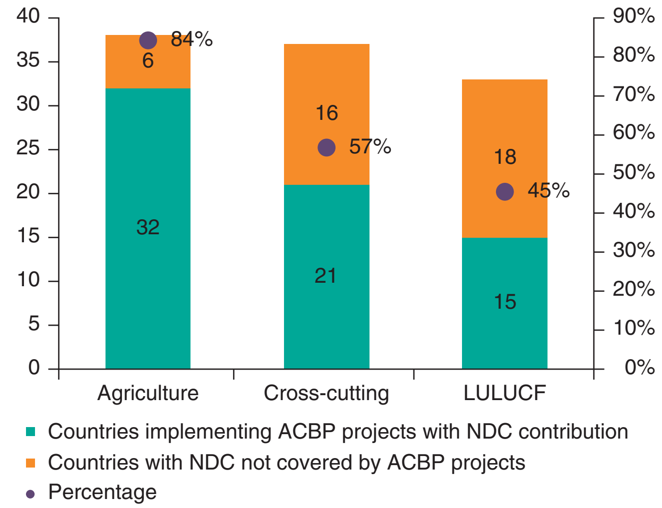
42. **Figure 3.2 shows that the ACBP portfolio contributes to a significant percentage of Sub-Saharan African countries' NDC implementation efforts in agriculture (84 percent); cross-cutting areas[10] (57 percent); and land use, land use change, and forestry (LULUCF; 45 percent).**

43. **At the sub-sector level, the ACBP portfolio makes important contribution (figure 3.3) to NDC implementation and targets related to CSA (85 percent), capacity building and knowledge transfer (73 percent), sustainable land management practices (69 percent), and food security (53 percent).** There appears to be much attention to agricultural practices that can be climate-smart (for example, crop and livestock management), but less to the enabling services (for example, climate services) that can facilitate adoption and full realization of the benefits of these practices.

44. **While this analysis generally shows evidence of significant alignment of the ACBP portfolio to implementing Ag-NDC commitments in Africa, detailed analysis of the prevalence and types of CSA technologies in the portfolio could help identify potential gaps and opportunities for additional support to countries.** Chapter 4 focuses on how CSA technologies have been scaled up in the portfolio.

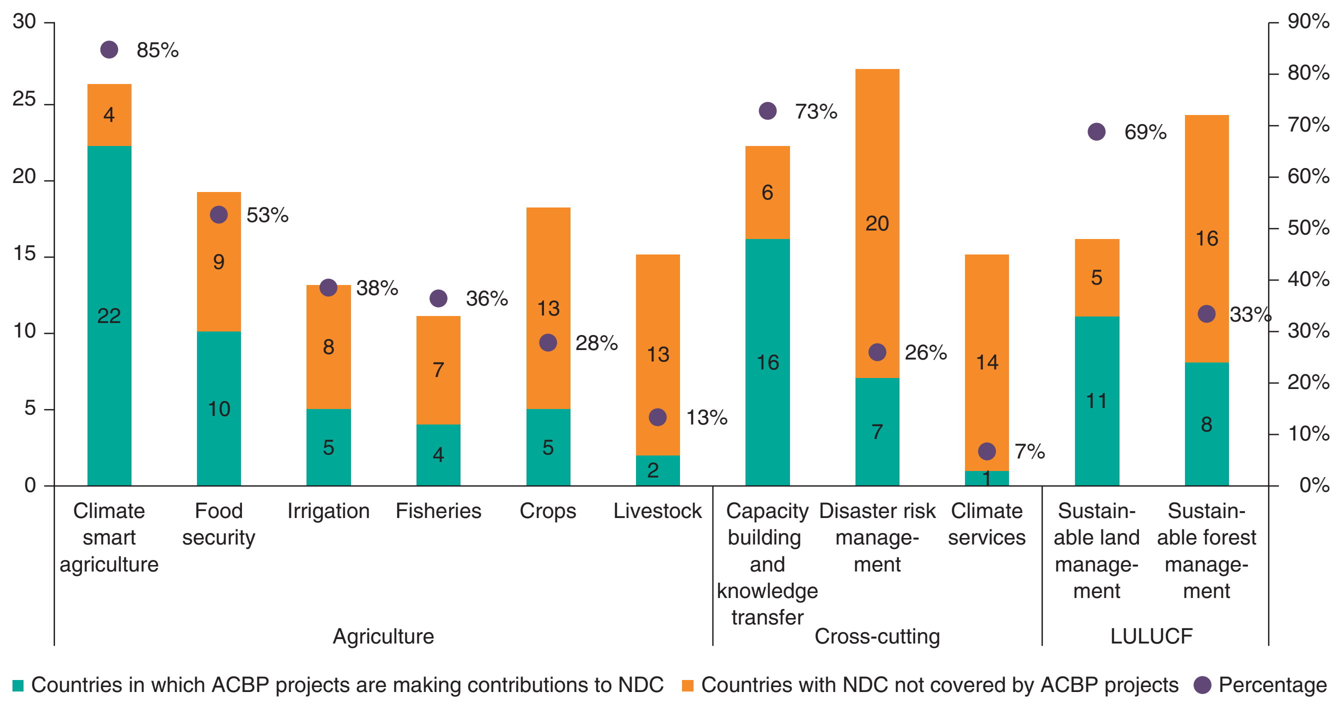
[10] Cross-cutting areas include capacity building and knowledge transfer, disaster risk management, and climate services.

FIGURE 3.2: COUNTRIES IMPLEMENTING ACBP PROJECTS WITH AND WITHOUT CONTRIBUTION TO NDC



Source: World Bank (2017c)

FIGURE 3.3: CONTRIBUTION OF ACBP PROJECTS TO NDC AT THE SUB-SECTOR LEVEL



Source: World Bank (2017c)

3.3 Establishment of climate-smart livestock development program

45. **As part of resources mobilization, a Program for Climate-Smart Livestock (PCSL) has recently been established through a joint initiative involving the German Development Agency (GIZ), the World Bank, and the International Livestock Research Institute (ILRI).** The program aims at fostering climate-smart livestock management practices, monitoring systems and policies across African countries, and providing guidance for scaling up lessons learned across the continent. The Program will intervene at several spatial scales and engage with various stakeholder groups in five fields of activity: (1) expanding action strategies for climate-smart livestock systems; (2) incorporating climate change mitigation and adaptation in livestock-related policies; (3) improving reporting on nationally determined contributions; (4) up-scaling interventions from climate change mitigation and adaptation in livestock at the regional level; and (5) channeling lessons learned by the Program into international discussion on agriculture and climate change. The program will further help improve production practices in the evolving livestock portfolio.

3.4 Analytical work on improving food systems' resilience to weather shocks

46. **During 2015–2016, record-high temperatures, droughts, and floods resulting from one of the strongest El Niño events in recent decades adversely impacted agricultural production across East and Southern Africa.** The El Niño event was the worst in 15 years; it was associated with massive crop failures in Southern Africa, floods in parts of East Africa, little or no harvests in many areas, and an extensive food security crisis. Increasing levels of concern over the mounting crisis prompted the World Bank to leverage funds from the Global Food Price Crisis Response Trust Fund to support countries' responses to the crisis and document lessons from the experience. The World Bank completed 11 analytical studies across East and Southern Africa countries on food security early-warning systems, emergency preparedness and response, and effective strategies to improve the resilience of agriculture and food systems to weather variability. The studies will underpin policy planning and future investments in scaling up CSA, in addition to supporting strategies for improving resilient outcomes among vulnerable smallholder farmers.

IV.

CSA Technologies and Practices in the ACBP Portfolio

47. **CSA includes practices and technologies that sustainably increase productivity, support farmers' adaptation to climate change, and reduce levels of GHGs.** Climate-smart approaches can include many diverse components from farm-level techniques to policies and finance mechanisms. CSA is not a prescribed practice or a specific technology that can be universally applied. It is an approach that requires site-specific assessments of the social, economic, and environmental conditions to identify appropriate agricultural production technologies and practices.

48. **CSA can be significantly scaled up using a variety of technologies, most of which rely on well-formulated and administered policies and enabling environments and investment climates.** The prevalence of CSA technologies in the ACBP agriculture portfolio was assessed for 49 projects for which relevant information is available in the project documents (table 4.1). The adaptation and mitigation benefits of the technologies are highlighted together with the time frame and challenges in implementing them.

49. **The adoption of CSA practices can face a variety of socioeconomic and institutional barriers.** These include the need for significant up-front expenditures on the part of poorer farmers, the non-availability of some inputs in the local markets, lack of information about the potential of improved techniques, and often limited capacity to implement the techniques. Certain techniques associated with CSA can be incompatible with traditional practices. In some instances, the diffusion of new technologies relies on a level of social capital and experience with collective action that farmers simply do not yet have (World Bank 2012). In discussing the adopted CSA technologies, this chapter highlights strategies to break some of the adoption barriers.

4.1 Improved livestock production

50. **Table 4.1 indicates that improved livestock management is the most prevalent set of CSA practices in the portfolio (63 percent)**. Hitherto, the critical contribution of livestock to the CSA agenda has been underexploited. Livestock production systems constitute a major economic sector for Africa (contributing an average of 40 percent of agriculture gross domestic product [GDP]), with small farms contributing most of the production in Africa[11] (Herrero et al. 2017). Hence the sector is important for reducing rural and peri-urban poverty. The sector also is critical for food security not only because of the income benefits but because of the nutritional benefits—animal source foods are protein dense and contain key micronutrients not found in plant-based foods (HLPE 2016). The growing demand for livestock products needs to be managed so that the production is as sustainable as possible, avoiding known negative environmental impacts of livestock, especially GHG emissions from enteric fermentation, nitrous oxide emissions from manure management, and GHG emissions caused by land use and land use change for feed and forage production.

51. **Improved livestock management focuses on four key elements.** The first element is improved feed and nutrition by planting better grasses and legumes and the incorporation of dietary supplements in livestock feeds. The second element is animal breeding and health care involving a range of practices that increase the resilience of animals and pastoral livelihoods. Such practices include introduction of heat-tolerant breeds; production and distribution of drought-tolerant feeds; adoption of modern reproductive management technologies targeting increased

[11] Across Sub-Saharan Africa, 25 percent of livestock production happens on farms less than 2 ha and 80 percent happens on farms less than 20 ha. (Herrero et al. 2017).

TABLE 4.1: PREVALENCE OF CSA TECHNOLOGIES IN THE ACBP PORTFOLIO

No.	CSA technologies	Features	Adaptation benefits	Mitigation benefits	Time frame for implementation	Implementation challenges	Number of projects	Relative proportion (%)
1	Improved livestock production	Improved feed and nutrition, animal breeding and health care, and land management.	Improved livestock breeds are more tolerant of heat or drought. Improved fodder species diversify the fodder source, help stabilize ecosystem services, improve soil's ability to retain water, hence, resilience to drought; and contribute to increase of manure management efforts and, hence, nutrition outcomes. In regions already marginal for crop production, as climate continues to warm, farmers may have to adapt more radically by abandoning cropping for livestock production.	Interventions to make the livestock sector more resilient deliver positive co-benefits for low carbon development. Interventions related to feed improvement reduce emissions intensities; that is, emissions per kilogram of meat and milk. Improved grazing management increases carbon sequestration in the soil and manure management and reduces emissions from the sector. Manure also can be captured for energy production.	Improved livestock varies from six months to a year; community-based breeding programs require 2 years minimum to train farmers to select for better adapted animals; disease surveillance programs require one to two years to establish and sustain. Integrating private/public health service providers into disease surveillance to make health inputs more readily available takes 6 months to a year.	Inadequate public and private partnership, awareness for access to improved high-quality drugs and vaccines, unreliable artificial insemination services, low awareness about techniques for improved local breeding management; underdeveloped feed and fodder value chain, and small land size also constrains farmers' ability to grow fodder crops.	31	63
2	Improved water management	Improved water management is rooted in efficient water use. A warming climate reduces water availability. Farmers need strategies that help reduce water use, while maintaining income and food production. This will require a shift from flood irrigation to drip irrigation, sprinkler, and water-harvesting techniques.	Enhances resilience to droughts and temperature increases. Improved water management helps in bridging dry spells, opening opportunities for additional dry season agricultural production.	Irrigation strategies that reduce the amount of water required can reduce energy consumption for pumping, thereby reducing emissions. Rainwater harvesting sequester more carbon compared to practices such as residue management, cover crops, manure and rotation diversification (World Bank 2012).	Provided water is available, the conception and planning of improvements can be achieved either with or by farmers themselves; can build on existing farming systems (rather than revolutionize them); can draw on local knowledge about resources, climate, and farming; and can be flexibly adapted to conditions during implementation and operation.	Farmers need better information on the benefits of the technology and early warning systems to optimize benefits of improved water management technologies. New short message service (SMS) systems to deliver field specific information and advice for irrigation scheduling are required.	28	57
3	Conservation agriculture (CA)	CA has its roots in the principles of providing permanent soil cover, minimizing soil disturbance, and rotating crops. Central elements	CA can increase options of crop-livestock integration and integration of trees and pastures into agricultural landscapes; crop residue retention reduces weed growth, reduces moisture	CA is 20 to 50 percent less labor intensive and, thus, contributes to reducing greenhouse gas emissions through lower energy inputs and improved nutrient use efficiency. It	CA is based on restoring naturally occurring processes and, therefore, needs a conversion period before the CA system is established and the natural balances are	CA is highly labor and knowledge intensive, requiring training and practical experience of those promoting. Therefore, its adoption levels are	26	53

TABLE 4.1: (Continued)

No.	CSA technologies	Features	Adaptation benefits	Mitigation benefits	Time frame for implementation	Implementation challenges	Number of projects	Relative proportion (%)
		include minimum/reduced tillage, no tillage, crop residue management, cover crops, crop rotation, and diversification.	loss, keeps the soil cooler, reduces erosion by water and wind, and restores soil carbon through decomposition. Cover crops penetrate and break up compacted soil layers; inclusion of legumes in crop rotations fixes nitrogen, thus, increasing yields and reducing expenditures on inorganic fertilizers; Diversification increases and builds up soil's resilience to climate change.	improves soil structure, stabilizes and protects soil from breaking down and releasing carbon into the atmosphere.	restored. This will require dedicated capacity-building programs: training of extension agents, lead farmers, and farmers to diffuse the technologies. It is advisable that farmers new to CA consult with practitioners to share experiences and set realistic expectations.	low across Africa, and farmers often use only some components selectively on small portions of land.	26	53
4	Agroforestry to diversify farms, improve food security, and capture carbon	Agroforestry is the integrated approach of producing trees and agricultural crops and/or livestock in a single farming system on the same piece of land. Intercropping with trees, tree-based farming, alley cropping, and improved fallow. Some 1.5 billion ha are suitable for some type of agroforestry in Africa.	Agroforestry fosters more efficient water utilization, improved microclimate, enhanced soil productivity and nutrient cycling, control of pests and diseases, improved farm productivity, and diversified and increased farm income. Tree shade over crops reduces ambient temperature by typically around 2°C; increases animal production by reducing heat stress in silvopastoral systems; reduces bare soil evaporation and improves water use efficiency of crops; trees increase water infiltration, reducing soil erosion and flood risk; plays an important role in water cycles at landscape and continental scales; Trees often complementary to other components producing fodder and food and stabilizing income through product diversification and nutrition.	Agroforestry systems increase carbon stored in vegetation and in soils, and through the production of substitutes for products that have higher emissions. Compared to single crop species, agroforestry systems have a higher potential to sequester because of their greater ability to capture and utilize light, water, and nutrient resources for growth. The amount of carbon sequestered depends on environmental conditions and systems of management. Higher soil organic carbon is associated with higher species richness and density. Tree-based cropping systems store more carbon in deeper soil layers. Agroforestry also helps to reduce pressure on natural forest, thereby reducing emissions associated with land use change (deforestation).	Implementation time frame depends on the initial conditions and can vary from as little as 6 months to 2–5 years when planting fruit trees from seedlings, to a decade when agroforestry is viewed as part of natural regeneration processes. In *Gliricidia*-based systems, it takes as little as 2–3 years for farmers to start reaping benefits in the form of nitrogen fixation and pruning of trees for firewood.	Agroforestry often includes significant upfront expenditure that farmers cannot afford. Bridging the time-gap between investments in trees establishment and obtaining returns is crucial. Maintenance costs can also be prohibitive for smallholder farmers. Lack of enabling environment in respect of markets for agroforestry products and policies that promote, rather than discourage tree management also is a major factor. Forest legislation and land tenure policies should be clearly defined for agroforestry system to thrive.	23	47

(*continued*)

TABLE 4.1: (Continued)

No.	CSA technologies	Features	Adaptation benefits	Mitigation benefits	Time frame for implementation	Implementation challenges	Number of projects	Relative proportion (%)
5	Digital agriculture	Big data analytics, information and communications technology applications, agricultural input scheduling and management, tailored SMS for better agronomic management, and climate and market advisories for risk management.	Enables analyses on a larger scale that can inform adaptation planning across landscapes or regions for higher productivity; combining climate information with good quality, site-specific data on factors such as soil fertility and erosion risk enables decision making on the sustainable productive potential of land in the near and long term.	More efficient fertilizer and other input use matched to climatic trends can help reduce their carbon footprint.	Months of integrating digital channels with existing climate services and deeper analytics will be required—ideally in the context of an alliance with a provider (e.g., a mobile network operator or value-added service provider) that has an interest in taking a solution to scale.	Technical capacity is a major constraint. Poor access to good quality data from providers of climate services and from farm locations; little experience leveraging the richness of the digital economy in their countries; digital service providers may also need to be aided to target agriculture. Majority of smallholder farmers live in remote areas, where good, fast internet connectivity reaches a small proportion of the population.	19	39
6	Stress tolerant varieties	Drought, heat, acidity/ salinity, and low soil fertility tolerance.	In the short term, crops bred for greater drought tolerance and shorter-duration varieties can both be used for "terminal drought escape". Breeding for resistance to the pests and diseases induced by weather events provides another important source of climate risk reduction. In the long term, as climate continues to warm, planting heat-tolerant, drought-tolerant or salinity-tolerant crop varieties, or by switching to crops that have higher tolerance to temperatures and the greater risk of drought will be important adaptation strategies. Another adaptation strategy is the substitution	Environments affected by salinity and droughts are inherently associated with low methane emissions, hence, the propagation of salinity-tolerant and drought-tolerant rice varieties for low carbon development. Likewise, the replacement of traditional varieties grown by short-maturity varieties has reduced flooding periods and, thus, the amount of methane emitted per season.	New varieties can be developed and released within 5–7 years.	Slow varietal replacement; need to ensure complementarity among new varieties, seed systems, and crop management practices. Political and institutional bottlenecks including restrictive seed policies, limited number of seed producers, and poor marketing and distribution can restrict smallholder farmers' access to new seeds.	18	37

TABLE 4.1: (Continued)

No.	CSA technologies	Features	Adaptation benefits	Mitigation benefits	Time frame for implementation	Implementation challenges	Number of projects	Relative proportion (%)
			of potentially vulnerable annual crops with more hardy perennials. In regions which are already marginal for crop production, farmers may well have to adapt more radically by abandoning cropping for livestock production.					
7	Integrated Soil Fertility Management (ISFM)	Soil fertility management technique that combines high-yielding varieties with organic materials (crop residue, mulching, manure, composting, and so on) and inorganic fertilizer.	Organic inputs (crop residues and manure) help to increase crop response to mineral fertilizer, replenish soil organic matter, and improve soil moisture storage capacity, thereby increasing agroecosystem resilience.	ISFM maximizes the use of organic matter that provides nutrients, sequesters carbon, and enhances water storage to minimize GHG emissions through reduced traffic and tillage and efficient use of organic and inorganic fertilizers.	Time frame varies. To achieve effective adoption, there is need for farmers to have improved access to quality inputs, information, off-takers and credit.	High transaction costs of input and farm produce trading; shortage or non-availability of credit facilities for making initial investment; aversion to risks surrounding the profitability of inputs; cost and availability of labor; land size and property rights; weak social networks and pervasive distrust; lack of information about soil fertility and rainfall forecasts that leads to optimum benefits; and scarcity of organic residues and competition for residues with livestock.	18	37
8	Biogas development	Capturing biogas from anaerobic processes	Source of energy for electric generators, heating, or lighting	Reduces carbon dioxide emissions. Energy generated in this way can offset CO_2 emissions from burning fossil fuels.	This will vary depending on availability of resources. A small family size digester (10 m^3 or less) can take about 1–2 months to have a functioning biogas plant.	Labor intensive as biogas production involves resource collection and removal of slurry daily. Scarce resources require additional labor for transportation.	7	14

(continued)

TABLE 4.1: (Continued)

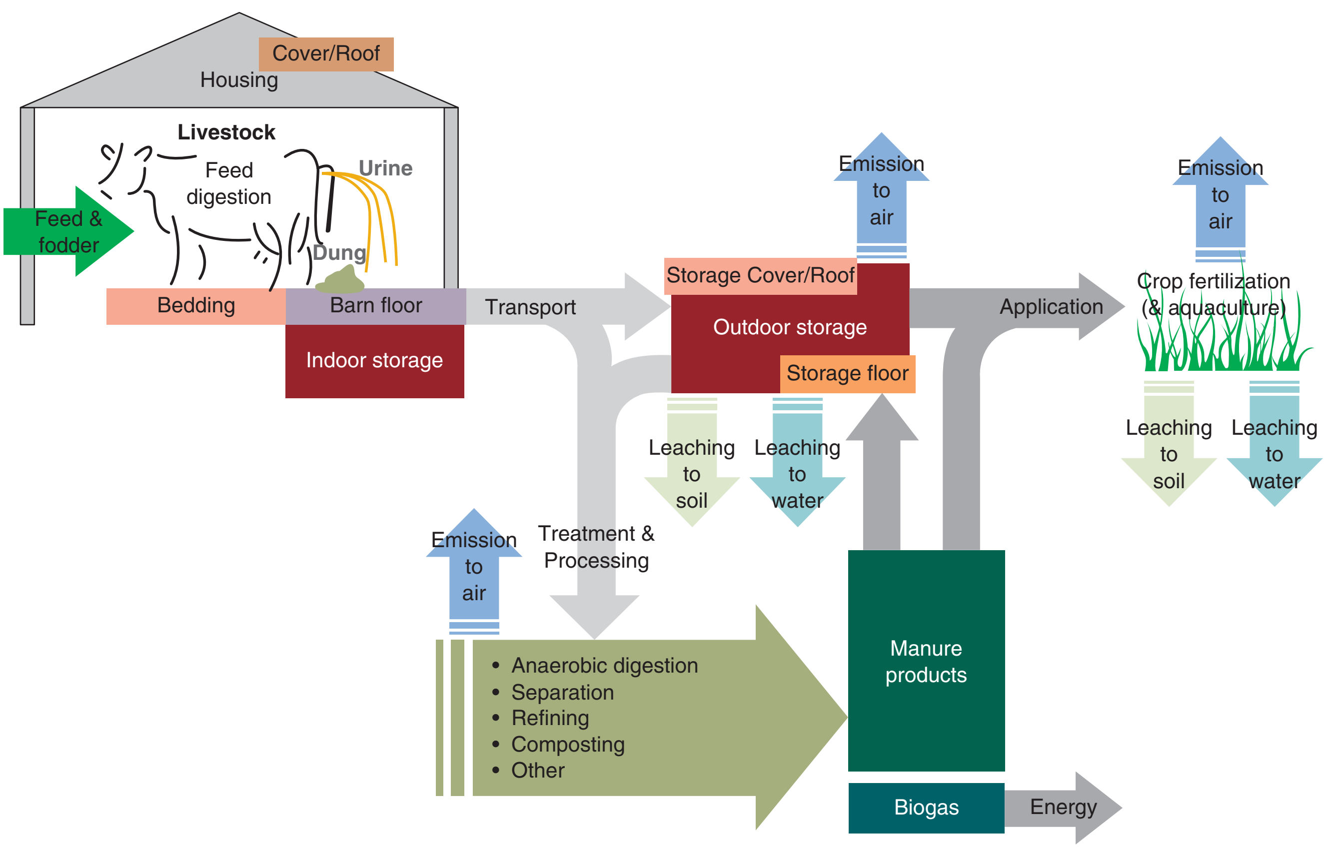
No.	CSA technologies	Features	Adaptation benefits	Mitigation benefits	Time frame for implementation	Implementation challenges	Number of projects	Relative proportion (%)
9	Alternate wetting and drying (AWD) in rice systems	Periodic drying of rice field by suspending irrigation for several days. Fields are irrigated again after some time so that there will be sufficient water available for rice plants.	Water saving potential is 15%–40%; facilitates a more equitable distribution of water resources to areas that typically suffer from water shortages; reduces uptake of arsenic in contaminated soils.	AWD has one of the highest GHG mitigation potentials of all climate actions in the agriculture sector reaching from 30%–70% of methane emissions under continuous flooding.	AWD can, in most instances, be adopted immediately.	Weed growth may increase under more aerobic conditions; change in perception and behavior of traditional rice farmers; and provides only limited incentives as a standalone technology.	3	6
10	Weather index-based agricultural insurance	An innovative approach to insurance provision that pays out benefits based on a predetermined index (for example, rainfall level) for loss of assets and investments resulting from weather and catastrophic events.	This can enhance farmers' willingness to invest in farm productivity by their knowing that the insurance will very likely pay out in the event of a climate shock; increases the confidence of credit providers to lend to smallholder farmers; enhances adoption of improved production technologies.	Mitigation benefits will depend on the degree to which insured farmers are able to invest in technologies and practices that enhance carbon sequestration and/or reduce greenhouse gas emissions.	Time frame for establishing an index-based insurance scheme can vary from 12–24 months depending on institutional capacity and availability of relevant data.	Technical challenges relate to data unavailability, technical capacity for product design, and pricing. Good weather and crop data are unavailable in many countries. Many farmers are not familiar with insurance practices and the basic concepts of insurance transaction. Poor legal and regulatory environment for enforcing contracts that both buyer and seller can trust.	1	2

Source: Compiled from Dinesh et al. (2017); and World Bank (2012, 2016a) fecundity; promoting artificial insemination (AI) technologies for increased productivity; prevention, eradication, and control of livestock diseases; and selection of low methane-producing animals.

52. **The third element is sustainable land management, including silvopastoral practices, a land use system that integrates trees and shrubs into pastures, and rotational grazing of livestock.** Silvopastoral systems can effectively promote economic, ecological, and social sustainability of pastoral livelihoods. Shade trees reduce heat stress on animals and help increase productivity. Trees improve the supply and quality of forage, which can help reduce overgrazing and curb land degradation. The last element is integrated manure management, which entails the optimal, site-specific handling of livestock manure from collection, through treatment and storage up to application to crops and aquaculture. The main aim is to prevent nutrient losses and, thus, save as many nutrients as possible to fertilize crops and improve soil health (figure 4.1). Nutrient losses from livestock manure can have detrimental effects on the environment in the form of emissions of methane, nitrous oxide, and ammonia, or release of nitrate and phosphate into water-bodies. Methane also can be captured for domestic uses, thereby reducing the pressures on woodcutting for firewood and charcoal.

53. **The mitigation potential of the livestock sector may represent up to 50 percent of the mitigation potential of global agriculture, forestry, and land use (Herrero et al. 2016).** Most of this potential is

FIGURE 4.1: INTEGRATED MANURE MANAGEMENT CHAIN



Source: Teenstra et al. (2015)

BOX 4.1: LIVESTOCK SECTOR DEVELOPMENT SUPPORT PROJECT IN BURKINA FASO

The project supports the Government of Burkina Faso to improve the productivity of dominant sedentary livestock value chains by enhancing producers' access to essential livestock inputs and the provision of technical support services. The project covers improved animal nutrition and access to genetic materials. It enhances animal feed quality control by developing feed quality standards and animal nutrition guidelines, facilitates the production and distribution of certified and improved forage seeds, strengthens the national genetic improvement program by distributing high performance bulls to selected farmers for breeding purposes, boosts AI services by upgrading the facilities and equipment of the *Centre de Multiplication des Animaux Performants* (CMAP), and supports the development and implementation of the regulatory and institutional framework for animal genetic resources. The project also supports the introduction of improved fingerlings to promote the production of sustainable fish ponds through the supervision of the General Directorate of Fisheries (DGRH).

yet to be realized, due to low rates of adoption and tradeoffs. Countries with investments in improved livestock production are shown in figure 4.2.

54. **Complementary to the expanding investments in improved livestock production is the implementation of the PCSL in Africa through a joint World Bank-German initiative.** The Program aims at fostering climate-smart livestock management practices, developing monitoring systems and policies, and providing guidance for upscaling climate-smart livestock practices across the continent. The initiative will assist governments in fulfilling their commitments[12] to achieve climate change adaptation and mitigation goals, and ultimately, to attract further national and international investment for CSA in general.

4.2 Improved water management

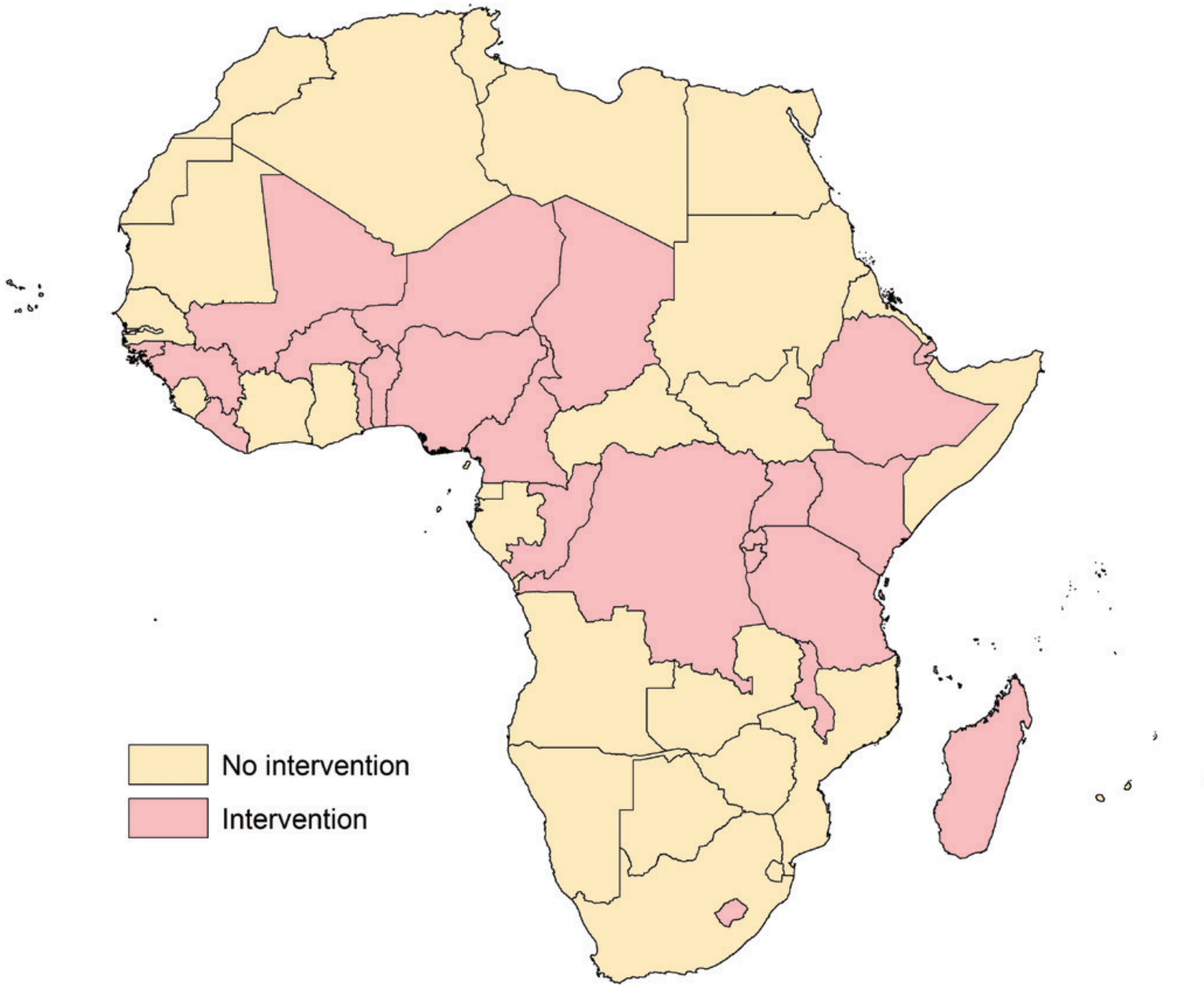
55. **Improved water management is present in 57 percent of the CSA portfolio (figure 4.3). Improved water productivity in agriculture is achieved by reducing water loss, harvesting water, managing excess water, and maximizing water storage.** Micro-irrigation techniques are promising systems for increased water use efficiency. Within micro-irrigation, a small volume of water is applied at frequent intervals to the spot where the roots are concentrated. Micro-irrigation techniques are gaining popularity among small-scale farmers, especially those systems using water harvested in tanks and small ponds.

56. **The most common micro-irrigation system is drip irrigation in which water flows under pressure through a filter into drip pipes with emitters located at variable spacing.** Water is discharged directly onto the soil near the plants. Drip lines should be placed close to the plants to avoid salt accumulation in the root zone and minimize water loss. Fertilizers and nutrients can be applied easily, and more precisely, through the system.

57. **Rainwater harvesting is particularly important for rain-fed agriculture in arid and semiarid regions.** Rainwater harvesting involves collecting and concentrating rainfall to make it available for agricultural or domestic uses in dry areas where moisture deficiency is the primary limiting factor,

[12] Specifically, the targets outlined in the NDCs, Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Plans (NAPs), and other climate change action plans.

FIGURE 4.2: COUNTRIES WITH IMPROVED LIVESTOCK PRODUCTION INTERVENTIONS IN THE CSA PORTFOLIO



Source: Authors

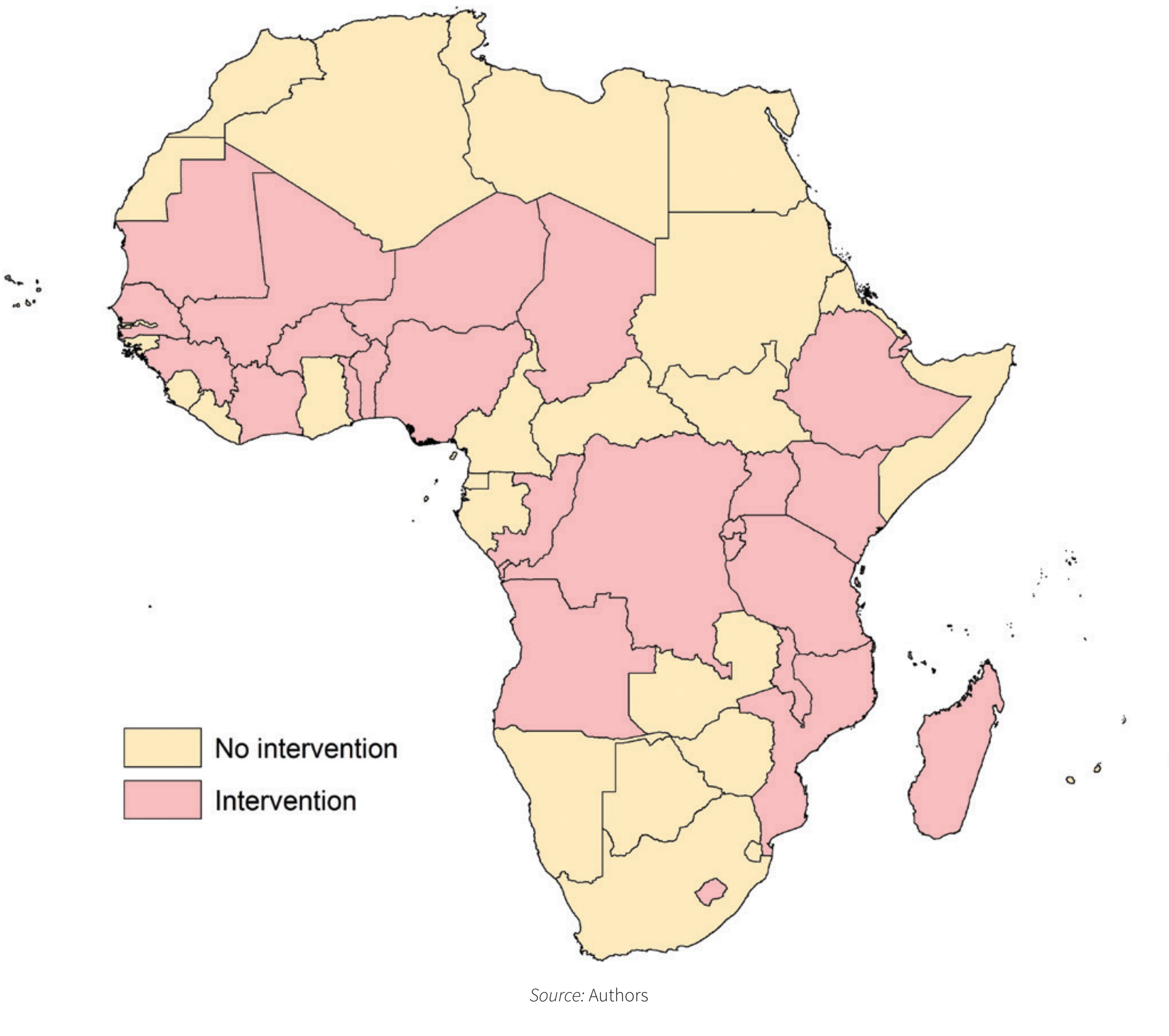
mostly in arid and semiarid regions. The practice aims at minimizing the effects of seasonal variations in water availability due to droughts and dry periods and enhancing agricultural production (box 4.2). The benefits of improved water management are maximized by supporting innovations and management practices that improve water use efficiency—for example, agronomic practices that identify, update, and disseminate knowledge on critical irrigation for different crops. Figure 4.3 shows countries with investments in improved water management in the CSA portfolio.

BOX 4.2: WATER HARVESTING IN MALAWI

Guided by the Post Disaster Needs Assessment (PDNA) Drought Recovery strategy for ensuring sustainability of recovery and resilience building in the food sector, the Malawi Drought Recovery and Resilience Project design includes the improvement of agricultural productivity, enhanced cultivated area under assured irrigation, and expanded livelihood options for vulnerable populations.

The project aims to strengthen water resource and catchment management through financing the rehabilitation of critical and duly prioritized small earth dams and associated catchments, as well as the construction of new water-harvesting structures (excavated tanks) to augment water availability in the drought-affected areas. This includes rehabilitation of around 20 small earth dams; construction of around 28 water-harvesting structures; water resource catchment rehabilitation and protection for selected hotspot areas; and technical assistance (TA) for feasibility studies, engineering design, and construction supervision.

FIGURE 4.3: COUNTRIES WITH IMPROVED WATER MANAGEMENT INTERVENTIONS IN THE CSA PORTFOLIO



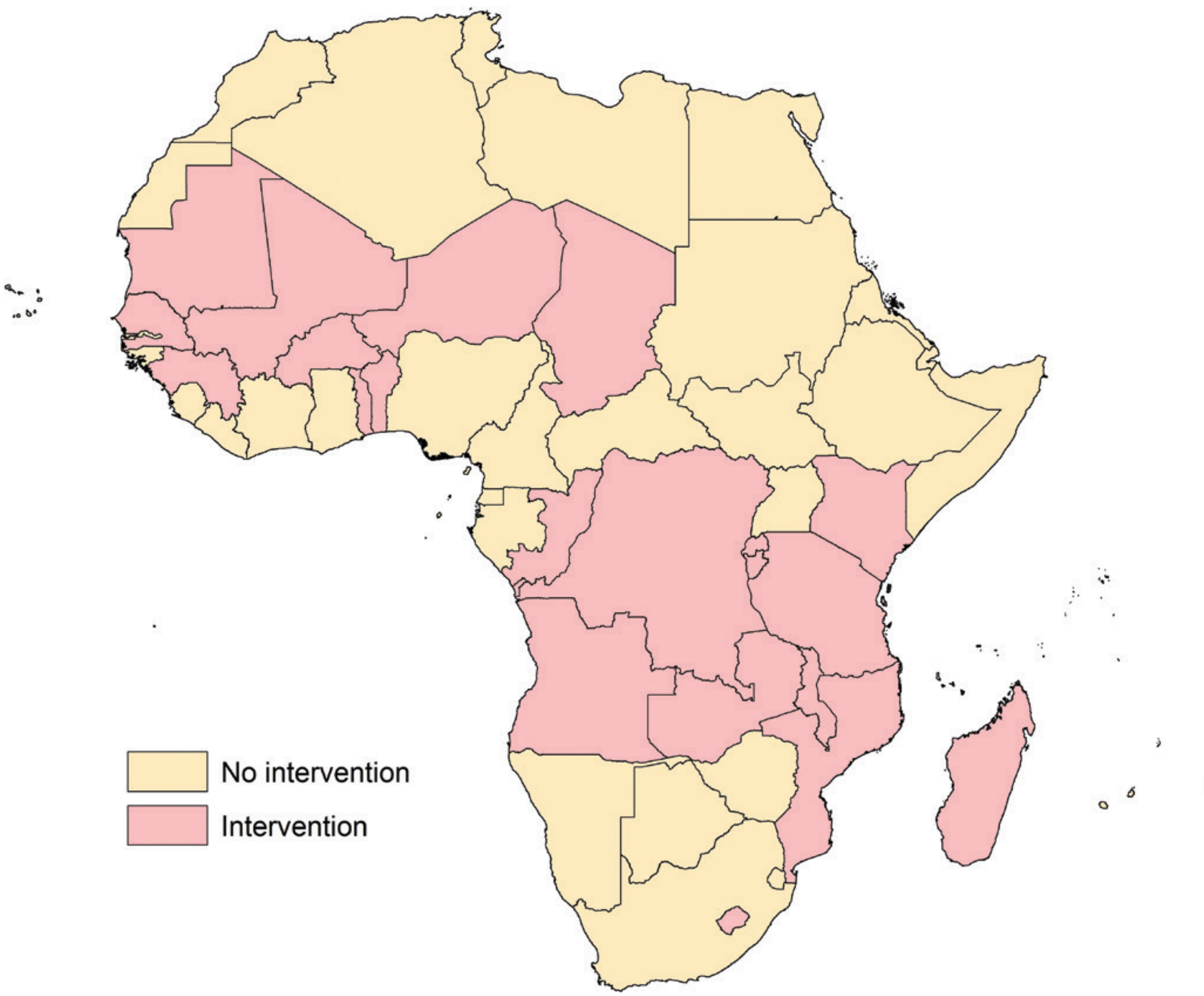
Source: Authors

4.3 Conservation agriculture (CA)

58. **CA is present in 53 percent of the projects portfolio (table 4.1).** CA is a farming system that conserves, improves, and makes more efficient use of natural resources through integrated management of soil, water, and biological resources. In this report, CA is recognized as any combination of the three fundamental components: minimum soil disturbance, permanent soil cover, and crop rotation. Each of the components of CA can serve as an entry point to the technology; however, only the simultaneous application of all three results in full benefits. However, partial adoption of selected components of the CA technology package is usually adopted by farmers due to financial-, land-, and risk-related constraints.

59. **CA has been proven to work in a variety of agroecological zones and farming systems, including high or low rainfall areas, degraded soils, multiple cropping systems, and in systems with labor shortages or low external-input agriculture (figure 4.4).** It has good potential in

FIGURE 4.4: COUNTRIES WITH CA INTERVENTION IN THE CSA PORTFOLIO



Source: Authors

dry environments due to its water-saving ability, though the major challenge here is to grow sufficient vegetation to provide soil cover. CA increases tolerance to changes in temperature and rainfall, reduces soil erosion, helps stabilize crop yields, and is, thus, an important technology for increasing agroecosystem resilience. Critical constraints to adoption are competing uses for crop residues, increased labor demand for weeding, and limited access to external inputs. CSA projects in the ACBP portfolio are addressing these constraints through support for specific material inputs, including minimizing herbicide use and providing training and technical guidance to increase adoption. Strategies to enhance the productivity and climate benefits of CA include developing cost-effective inoculants through public-private partnerships. Scaling up the application of nitrogen-fixing microbes to boost yields, strengthen resilience, and reduce heat, stress, and pest infestation associated with climate variability also is crucial.

4.4 Agroforestry to diversify farms, improve food security, and capture carbon

60. **Agroforestry occurs in 47 percent of the CSA portfolio (table 4.1).** Agroforestry is an integrated land use system combining trees and shrubs with crops and livestock. Agroforestry maintains soil organic matter and biological activity at levels suitable for soil fertility. Trees in the farming system can help increase farm incomes and diversify production, thus mitigating production and market risk associated with any one commodity. This will be increasingly important as impacts of climate change become more pronounced. Trees and shrubs can diminish the effects of extreme weather events, such as heavy rains, droughts, and wind storms. They prevent erosion, stabilize soils, increase infiltration rates, and halt land degradation. They can

enrich biodiversity in the landscape and increase ecosystem stability. Greater yields and reduced variability can be expected on adjacent croplands and better rainwater management in the medium-to-longer term. Agroforestry is a major source of carbon sequestration in agricultural landscapes.

61. **Agroforestry is one of the most conspicuous land use systems across landscapes and agroecological zones in Africa.** It provides five main benefits: food, fuel, fertilizer, fiber, and fodder.[13] Intercropping with leguminous trees increases yields. A significant proportion of rural households use fuel wood 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.

62. **Agroforestry has shown enormous promise for co-delivery of climate adaptation and mitigation benefits in addition to improving food security in Africa.** Investing in agroforestry on 25 percent of cropland (75 million ha) of land 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 of carbon dioxide equivalent 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.

63. **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.*

64. **It can sometimes take up to five years for *Faidherbia* and other trees in agroforestry systems to generate economic returns.** Thus, farmers in the Eastern Province of Zambia are turning to *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. Figure 4.5 indicates countries with agroforestry intervention in the World Bank's CSA portfolio.

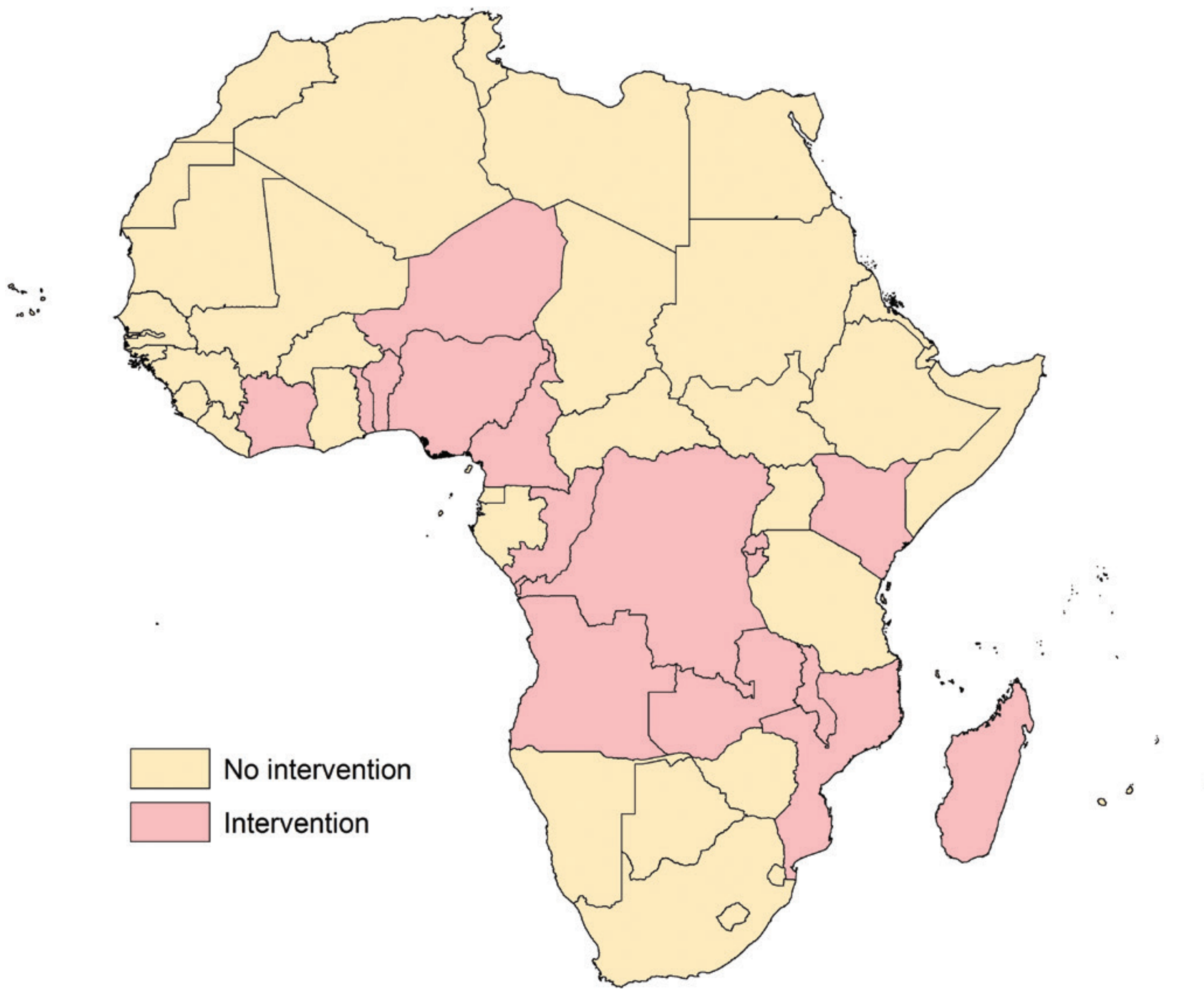
4.5 Digital agriculture for increasing productivity and resilience

65. **Digital agriculture entails the use of digital technologies, such as the Internet of Things (IoT) and analytic capabilities integrated into one system to make farming more precise, productive, and profitable (figure 4.6).** New digital technologies make it possible to collect and leverage huge amounts of critical data at minimal costs—thus making a farm's field operations more insight-driven and potentially more productive and efficient.[14]

66. **Typical applications of digital agriculture include variable-rate treatments (VRTs),[15] yield prediction through remote sensing, disseminating improved agronomic information through an Interactive Voice Response System (IVRS), input voucher system, digitally delivered financial services, and integrated agro-weather**

[13] Evergreen Agriculture Partnership. http://evergreenagriculture.net/what-is-evergreen-agriculture/ http://www.fao.org/docrep/014/i1861e/i1861e.pdf.
[14] ICRISAT. Digital Agriculture: Pathway to Prosperity. http://www.icrisat.org/digital-agriculture/.
[15] VRT allows the farmer to utilize field variability information and plan inputs (seeds, fertilizers, and pesticides) so that the best potential of the field is obtained.

FIGURE 4.5: COUNTRIES WITH AGROFORESTRY INTERVENTIONS IN THE CSA PORTFOLIO



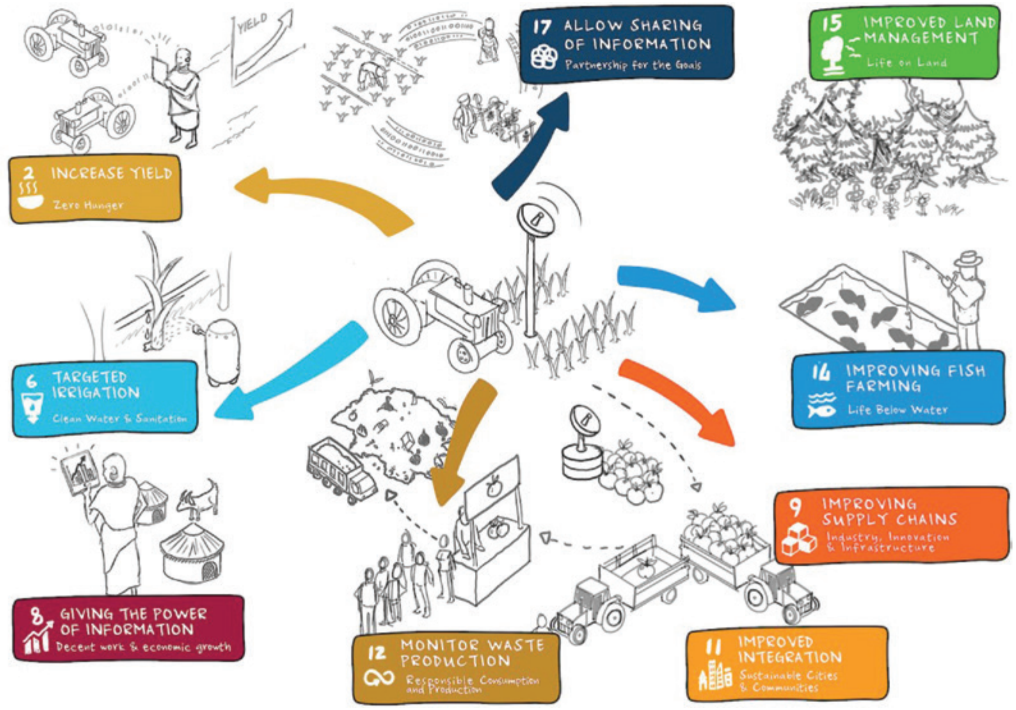
Source: Authors

and market advisories delivery for farmers.[16] A major application of digital agriculture in the CSA project portfolio is in the design and delivery of integrated weather and market advisories to farmers using big data analytics (box 4.3). This helps inform farmers' decisions about what to grow, when to plant and harvest, how to allocate their labor, and where to sell their produce. The resulting combined data is analyzed and interpreted so that the farmer can make more informed and personally relevant decisions (figure 4.7), leading to increased yields and resilience. Rural connectivity is vital to providing low-cost data and access to information for farmers in Africa.

67. **Application of digital agriculture across the value chain has the potential to make agriculture more productive in addition to increasing resilience to climate change.** More efficient input use matched to climatic trends can also help reduce GHG emissions. Figure 4.8 indicates countries with digital agriculture in the agriculture portfolio.

[16] United Nations Global Compact. Digital Agriculture: Feeding the Future. http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/.

FIGURE 4.6: POTENTIAL APPLICATION OF DIGITAL AGRICULTURE TO SUSTAINABLE DEVELOPMENT GOALS



Source: Accenture (http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/)

BOX 4.3: DIGITAL AGRICULTURE UNDER THE KENYA CLIMATE-SMART AGRICULTURE PROJECT

The Kenya Climate-Smart Agriculture Project (KCSAP) aims to enhance agro-weather forecasting and marketing information system and their dissemination tools by improving agrometeorological forecasting and monitoring through mapping existing publicly and privately operated automated weather stations (AWSs), establishing agro-meteorological centers in participating counties to improve drought and flood forecasts, installing new automated agro-weather stations to complement existing infrastructure, and developing and upgrading the EWS at the Kenya Meteorological Department (KMD) and the National Disaster Management Authority (NDMA).

The project uses big data for climate-smart, agro-weather, and market information systems and advisories by segmenting and registering value chain stakeholders, establishing homogenous production zones to support a location-specific information system and advisories, collecting agricultural statistics, and setting up infrastructure for “big data” analytics. Big data based on crop/pasture-weather analytics will help farmers decide what, when, where, and how to plant.

The project strengthens the market information system by financing data capture for agricultural outputs (agriculture, livestock, and fisheries), inputs, storage, transport, and also matching producers and buyers; and delivering the integrated weather and market advisory services. Capacity strengthening is provided for Kenya Agriculture Livestock Research Organization (KALRO) to effectively deliver data and information services to various users.

FIGURE 4.7: TYPICAL ADVISORY SERVICES FOR SMALLHOLDER FARMERS

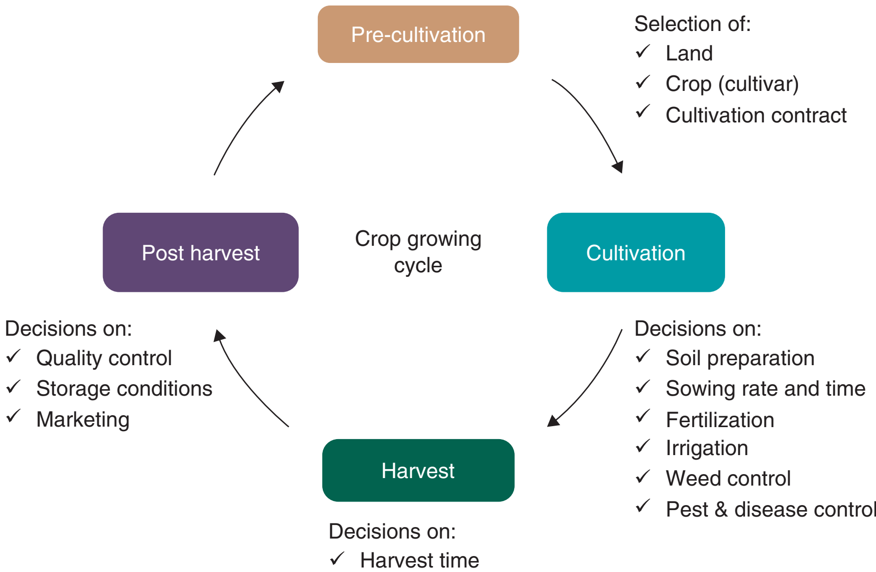
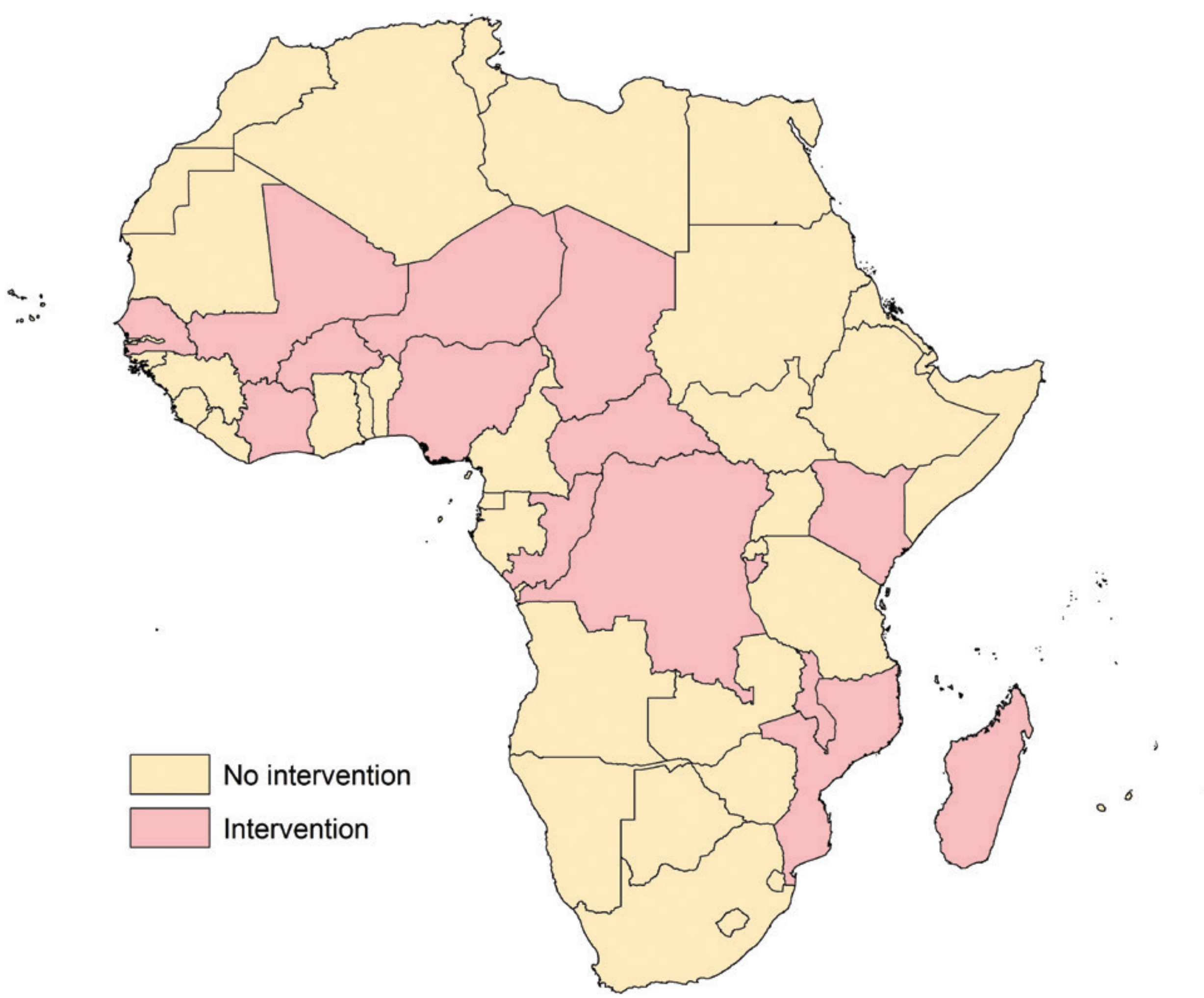


FIGURE 4.8: COUNTRIES WITH DIGITAL AGRICULTURE INTERVENTIONS IN THE CSA PORTFOLIO



Source: Authors

4.6 Stress-tolerant varieties for climate adaptation

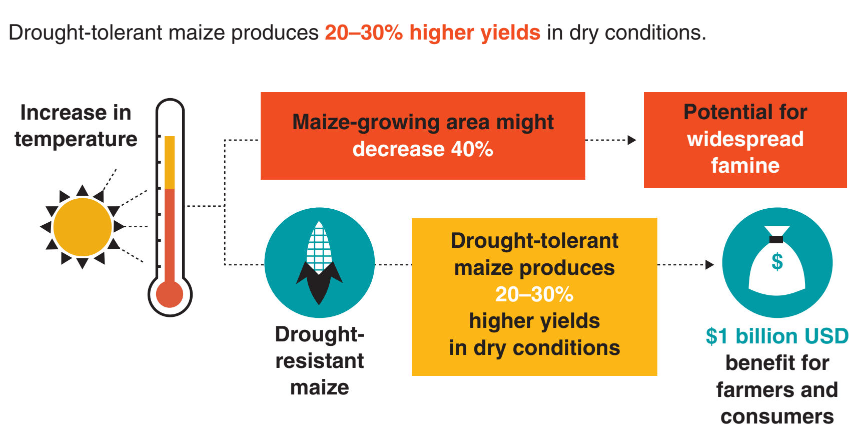
68. **Climate change has led to several stress factors—increased incidence of drought, heat, and extreme weather events, poor soil fertility, salinity, livestock, and crop diseases and pests—all of which can severely affect smallholders' income and livelihood.** All of this is compounded by the high price of inputs beyond the reach of farmers and a lack of credit facility. Stress-tolerant crops have increased physiological resistance to climatic extremes (figure 4.9). They are developed using innovative breeding tools and techniques to increase the rate of genetic gain for important multiple traits, including gender-preferred traits by the seed sector. Figure 4.10 indicates countries with drought-tolerant crop varieties in the CSA portfolio.

4.7 Integrated soil fertility management (ISFM)

69. **ISFM has 37 percent prevalence in the CSA portfolio.** It is a set of soil fertility management practices that involve combining improved germ plasm with judicious quantities of mineral fertilizer, and organic inputs. ISFM works best when adapted to local conditions to optimize agronomic nutrient use efficiency and improve crop productivity (figure 4.11). Genetic resources are critical elements for increasing the efficiency and resilience of agricultural systems. Improved germ plasm refers to seeds, seedlings, and other planting materials that have been bred to meet particular requirements of the environment in which they are to be grown, including high genetic yield potential, pest and disease resistance, drought resistance, and nutrient and water use efficiency. Mineral fertilizers supply essential nutrients to plants in readily available form but should be applied at the fastest crop-growing stage where they can provide the greatest benefits. Organic inputs—crop residues and manure—help increase crop response to mineral fertilizer, replenish soil organic matter, and improve soil moisture storage capacity, thereby increasing agroecosystem resilience.

70. **ISFM techniques can restore degraded soils and thereafter maintain soil fertility by using available nutrient resources in an efficient and sustainable way.** ISFM aims at making use of techniques without much additional cost to the farmer, such as organic fertilizer, crop residues, and nitrogen-fixing crops, in combination with seed priming and water harvesting. ISFM can sometimes be practiced in combination with other CSA practices like CA and agroforestry.

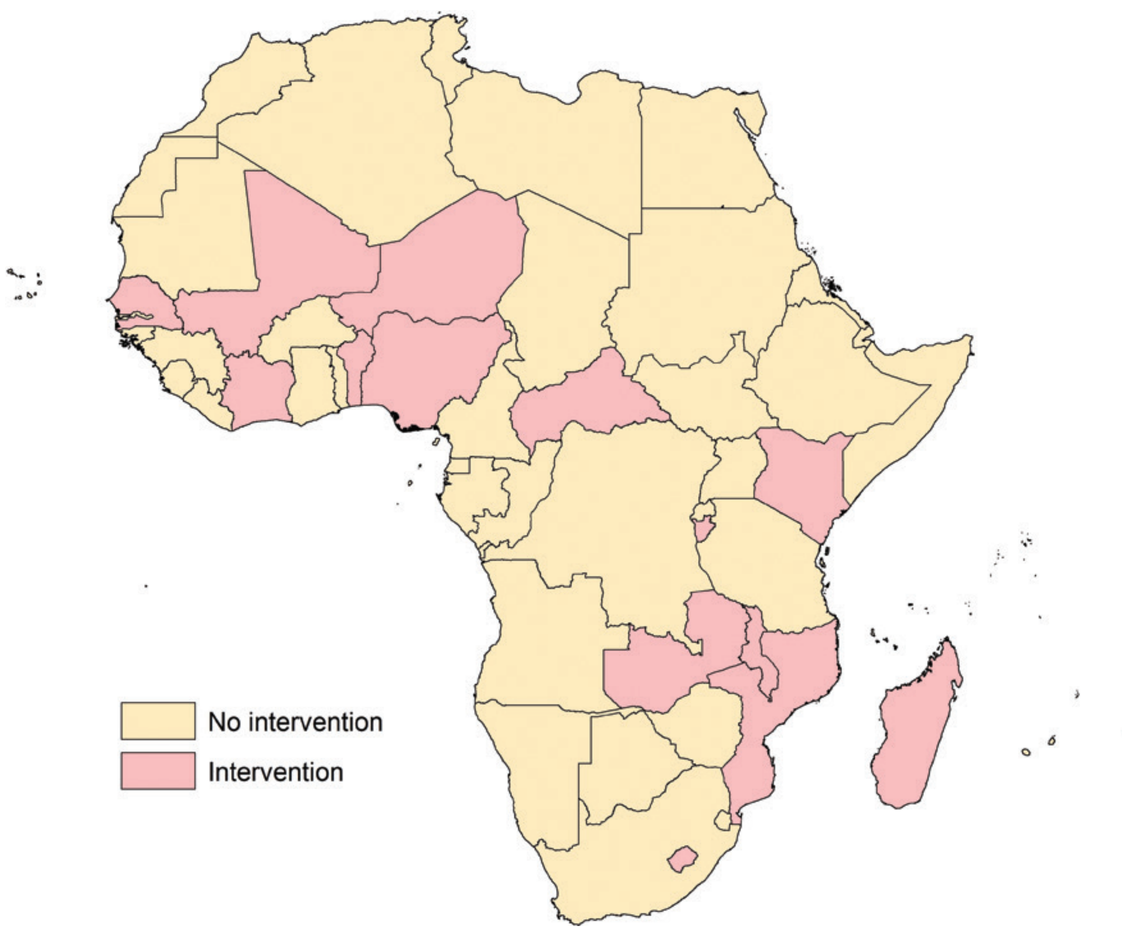
FIGURE 4.9: POTENTIAL OF DROUGHT-TOLERANT MAIZE VARIETIES



Source: Climate Change, Agriculture and Food Security (CCAFS 2013)[17]

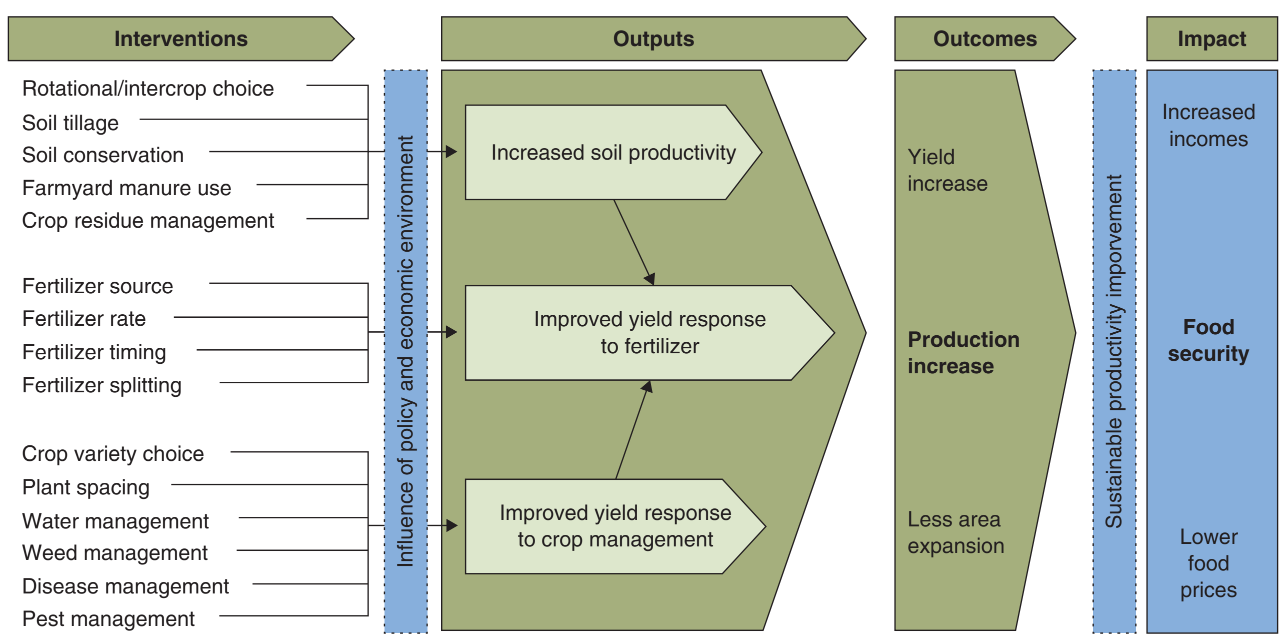
[17] Drought-tolerant Maize Boosting Food Security in 13 African Countries. https://ccafs.cgiar.org/bigfacts/#theme=evidence-of-success&subtheme=crops&casestudy=cropsCs2.

FIGURE 4.10: COUNTRIES WITH STRESS-TOLERANT CROP INTERVENTIONS IN THE CSA PORTFOLIO



Source: Authors

FIGURE 4.11: ISFM INTERVENTIONS AND BENEFITS



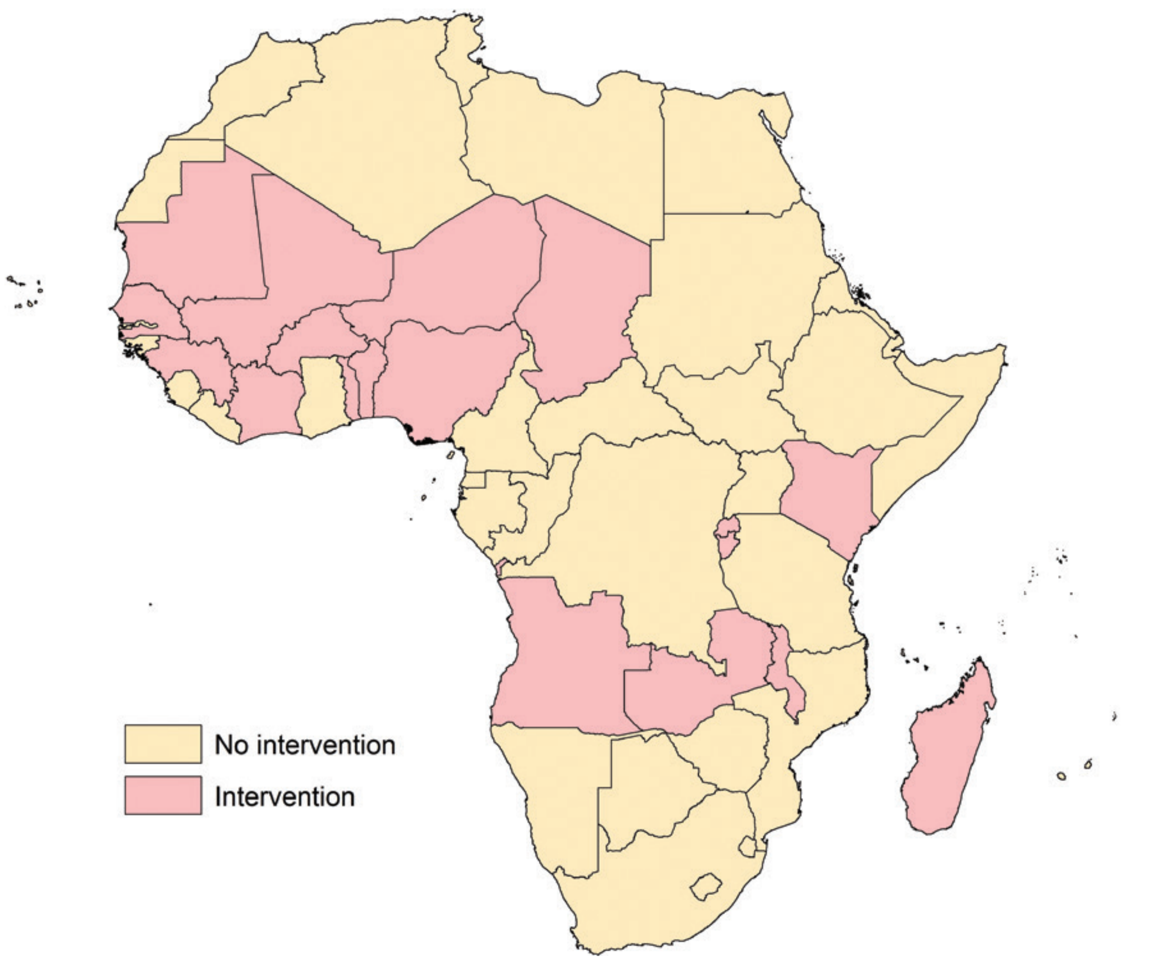
Source: Africa Soil Health Consortium[18]

[18] Africa Soil Health Consortium. *Handbook for Integrated Soil Fertility Management.* https://publications.cta.int/media/publications/downloads/1853_PDF.pdf

71. **Widespread adoption of ISFM practices is constrained by high prices of seeds and fertilizer, and accessibility and availability of material and markets (World Bank 2016a).** An example of a low cost ISFM technique is composting, which is the natural process of decomposition of organic matter, such as crop residues, farmyard manure, and waste by microorganisms under controlled conditions. It is an attractive proposition for turning on-farm organic waste into a farm resource and is gaining more importance among small-scale farmers in Sub-Saharan Africa. In addition to supplying nutrients, organic inputs also contribute to crop growth in other ways, by increasing the crop response to mineral fertilizer, improving the soil's capacity to store moisture, regulating soil chemical and physical properties that affect nutrient storage and availability, as well as root growth, adding nutrients not contained in mineral fertilizers, creating a better rooting environment, improving the availability of phosphorus for plant uptake, ameliorating problems, such as soil acidity, and replenishing soil organic matter.

72. **ISFM emphasizes the importance of optimizing the use of organic resources after exploring their opportunity cost (for example, comparing the retention of organic resources in the field with their use for livestock feed, mulch, or compost production).** Figure 4.12 indicates countries with ISFM intervention in the CSA portfolio.

FIGURE 4.12: COUNTRIES WITH ISFM INTERVENTIONS IN THE CSA PORTFOLIO



Source: Authors

4.8 Biogas development: from methane emissions to energy production

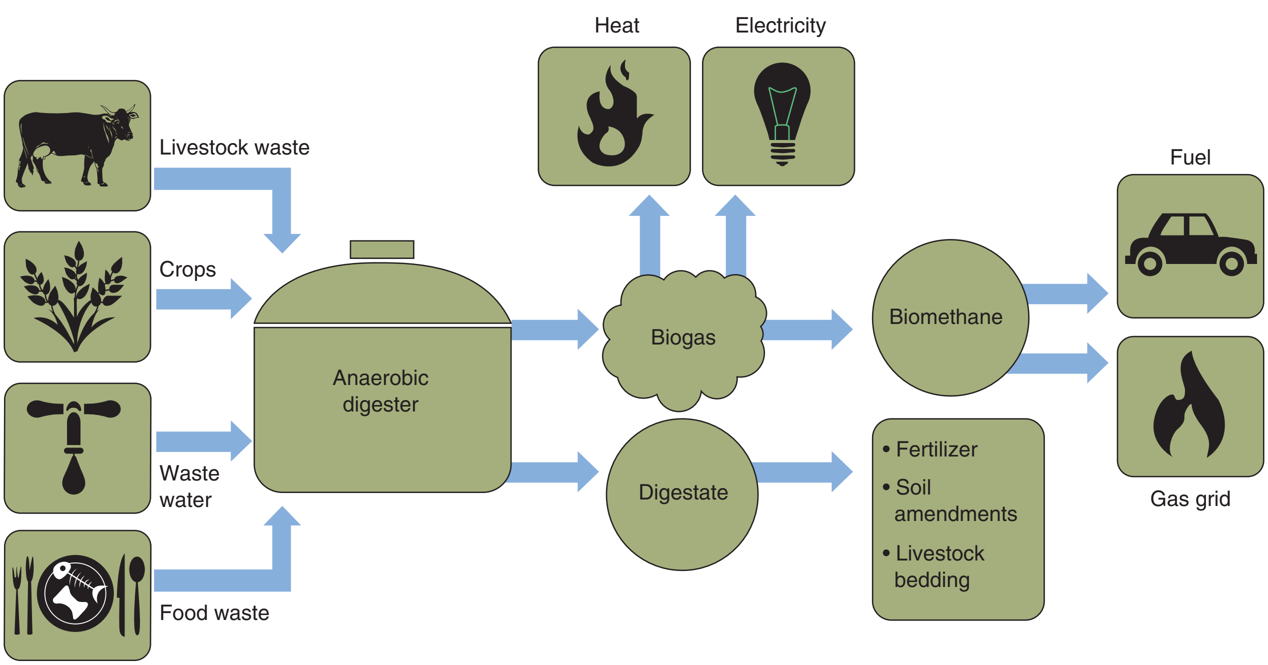
73. **Biodigestion or anaerobic digestion is a biological process that occurs when organic matter is decomposed by bacteria in the absence of oxygen.** As the bacteria decompose the organic matter, biogas is released and captured. Biogas consists of approximately 60 percent methane and 40 percent carbon dioxide. The remaining byproduct (digestate) is rich in nutrients and can be used to fertilize agricultural fields (figure 4.13). Biogas digesters (biodigesters or anaerobic digesters) are the systems that process waste into biogas and then channel that biogas so that the energy can be productively used.

74. **Biogas is an environmentally friendly energy source because it avoids the release of methane, a gas that is 25 times more powerful than carbon dioxide in its global warming potential.** Biogas also reduces the reliance on fossil fuel to meet energy demand. About one to two cows, or five to eight pigs, can supply adequate daily feedstock for a single-household biodigester. The daily input of dung and urine from a single cow produces 1–2 kWh of electricity or 8–9 kWh of heat. Such a household's biogas installation can provide sufficient energy for cooking and some lighting. The price of a small-scale digester varies widely between US$100–US$1,700.

75. **Experience with biogas plant installation differs among countries with biogas systems varying in scale depending on the characteristics of the livestock production system.** In subsistence farming systems, simple digesters require support for capital investments, but pay-back periods can be relatively short. The biogas is used as a source of energy for electric generators, heating, or lighting. Energy generated in this way can offset carbon dioxide emissions from burning fossil fuels. Figure 4.14 indicates countries with biogas development intervention in the World Bank's CSA portfolio.

76. **Despite its importance, biogas development is one of the least prevalent technologies (14 percent) in the projects portfolio.** A major constraint to adoption is the low level of awareness of the climate and health benefits of biogas. Second, installing a biogas plant entails significant expenditure that poor farmers cannot afford. The third reason is the absence of bioenergy policies and incentives to

FIGURE 4.13: ANAEROBIC DIGESTION PROCESS



Source: Environmental and Energy Study Institute. Fact Sheet–Biogas: Converting Waste to Energy. http://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy

FIGURE 4.14: COUNTRIES WITH BIOGAS DEVELOPMENT INTERVENTIONS IN THE CSA PORTFOLIO

Source: Authors

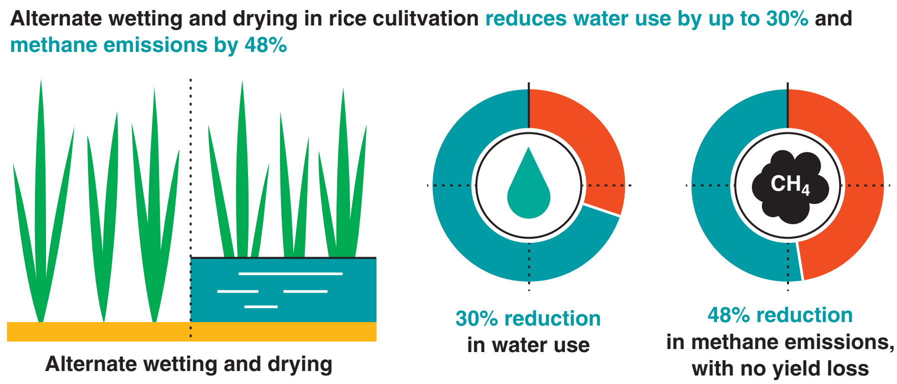
encourage investment in the technology in many countries. Fourth, skills in the design, construction, operation, and maintenance of biogas productions systems are markedly limited. Finally, animal grazing patterns and mixed crop-livestock systems present challenges in obtaining the necessary feedstock for anaerobic digestion.

77. **The Burkina Faso Livestock Sector Development Support Project addresses some of these constraints by providing technical support and matching grants for the design and installation of biogas plants in selected communities.** Consistent with the country's NDC priorities, the switch to biogas ensures diversification of energy sources with a lesser environmental footprint.

4.9 Alternate wetting and drying (AWD) in rice systems

78. **AWD is a water-saving technology applied to reduce irrigation water consumption in rice fields without decreasing yields.** In AWD, irrigation water is applied a few days after the disappearance of the ponded water. The field, therefore, gets alternately flooded and non-flooded. The number of days of non-flooded soil between irrigations can vary from 1 to more than 10 days depending on a number of factors, such as soil type, weather, and crop growth stage. AWD entails monitoring water levels above and

FIGURE 4.15: BENEFITS OF AWD RICE CULTIVATION



Source: CCAFS (2013)[19]

below the soil surface and only irrigating when they fall below certain levels. At other times, farmers allow the fields to dry. This reduces water use by up to 30 percent and methane emissions by about 50 percent without affecting yields and helps save farmers' money on irrigation and pumping costs (figure 4.15). AWD can also increase yields by promoting stronger root growth in rice plants. With efficient nitrogen use and application of organic inputs to dry soil, the practice can reduce emissions even further, enhance nutrient efficiency, and reduce pest infestation. Figure 4.16 indicates intervention areas for AWD in the ACBP portfolio.

4.10 Weather index-based agricultural insurance

79. **Despite increasing frequency of weather-related risks, most smallholder farmers, in low income countries, rarely have access to formal tools to help them manage the risks.** Crop insurance supplied by the private sector is essentially nonexistent in most countries due to large informational asymmetries and the high transaction costs of dealing with smallholder farmers. Farmers often rely on informal approaches to risk management, such as accumulating precautionary savings, planting lower-value crops that are less sensitive to weather fluctuations, and diversifying their sources of income away from the most profitable options. Innovations in insurance markets, such as index-based insurance, have the potential to address these problems by helping farmers' smooth incomes in bad years and helping governments and relief agencies respond quickly and fully to weather-related disasters when they occur. Index-based insurance links indemnity payments to easily observed outcomes—such as rainfall—instead of to individual farmer yields, typical in traditional insurance. Only one project in the CSA portfolio includes weather index insurance intervention (box 4.4).

80. **Several factors combine to make the implementation of weather index insurance challenging.** The technical challenges relate to data unavailability, technical capacity for product design, and pricing. Good quality weather and crop data are needed to ensure robust design of the index so that it sufficiently protects a farmer against the targeted risk and correlates well with losses. The major socioeconomic challenge relates to the farmers' low level of awareness of insurance practices, which can affect their expectations on indemnity payments. Most farmers also have low disposable incomes and are unwilling to pay premiums. The institutional challenge relates to the lack of legal and regulatory environment for enforcing index insurance contracts in many countries. Weather index insurance products show promise including for large-scale farmers who have clearly identifiable and insurable losses and revenue streams that enable them to pay premiums, as a financing tool for social protection against disasters, and as a portfolio risk management measure for financial intermediaries who lend to farmer groups.

[19] Drought-tolerant Maize Boosting Food Security in 13 African Countries. https://ccafs.cgiar.org/bigfacts/#theme=evidence-of-success&subtheme=crops&casestudy=cropsCs2.

FIGURE 4.16: COUNTRIES WITH AWD INTERVENTIONS IN THE CSA PORTFOLIO

Source: Authors

BOX 4.4: WEATHER INDEX INSURANCE IN MOZAMBIQUE

A major concern of banks extending agribusiness financing to farmers in Mozambique is the potential for losses because of severe weather events. Severe droughts and floods can have a serious impact of destroying crop production and significantly limiting the capacity of many smallholder farmers to repay their credit. The Mozambique Agriculture and Natural Resources Landscape Management Project includes a component that expands weather index insurance coverage under a pilot operation previously financed by the Global Index Insurance Facility (GIIF) from 43,000 to 102,000 farmers corresponding to about 40 percent of all cotton farmers in Mozambique. It also increases the amount of input cost coverage from 20 percent to 60 percent of the input costs; in addition to exploring additional value chains (for example, soybeans, maize, horticulture, peas, and cashews) for which weather index insurance can be implemented.

FIGURE 4.17: MOZAMBIQUE IS THE ONLY COUNTRY WITH WEATHER INDEX INSURANCE IN THE PROJECT PORTFOLIO

4.11 Capitalizing on synergies and managing trade-offs

81. **Trade-offs are inherent in the attempt to achieve the triple win of food security, resilience, and mitigation.** There is the need for policy makers and resource managers to manage trade-offs across space, time and sectors when addressing challenges related to poverty, food security, environmental degradation, and climate change. The multiple services provided by land interact in complex ways, leading to positive and negative impacts as the production of one ecosystem service increases.[20] Synergy results when the production of more of an ecosystem service leads to more of another. For example, intercropping, the growing of food crops near existing trees, provides synergy between productivity and increased soil carbon sequestration. On the other hand, trade-off, the

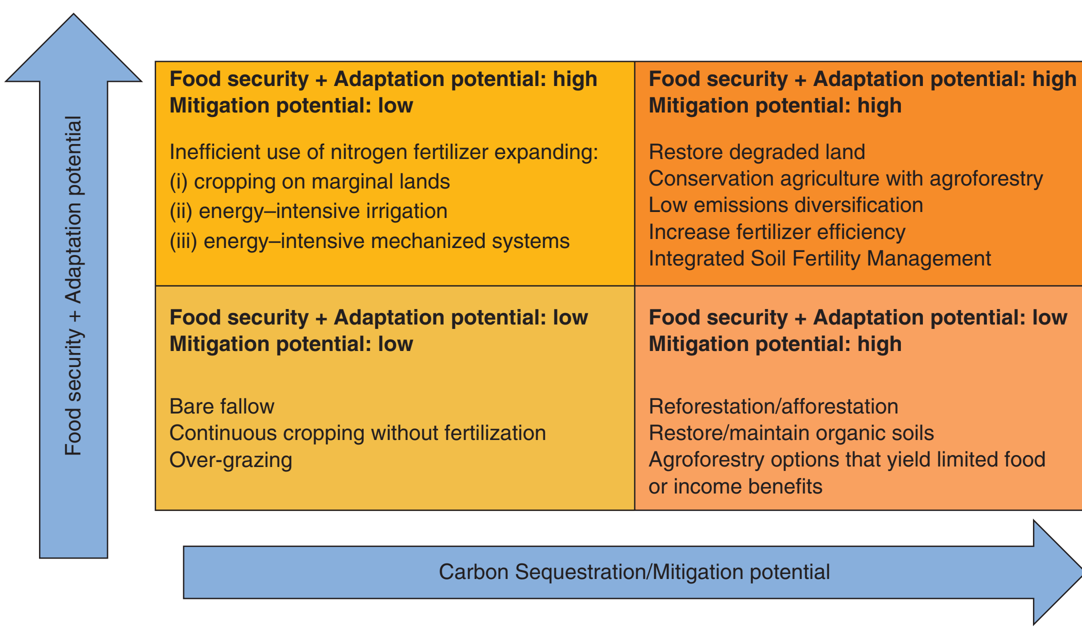
[20] Ecosystem services refer to the benefits we derive from nature and functioning ecosystems. They are grouped into four broad categories: *provisioning*, such as the production of food and water; *regulating*, such as the control of climate and disease; *supporting*, such as nutrient cycles and oxygen production; and *cultural*, such as spiritual and recreational benefits (http://www.millenniumassessment.org/documents/document.356.aspx.pdf).

more frequent outcome occurs when the production of one ecosystem service decreases the supply of another. An example of trade-off is attempting to increase soil carbon storage through afforestation which may reduce agricultural productivity, as afforestation tends to take land out of production for a significant period of time (figure 4.18). Conversion to agricultural land presents a trade-off to society, because the same land that is used for providing essential food, feed, fiber, and biofuels, could store large amounts of carbon in soils and biomass in its natural state, and thus, mitigate climate change. Globally, the expansion of croplands to satisfy the needs of a growing population with changing diets is causing a costly loss in carbon stocks in natural vegetation and soils.[21]

82. **Working at the landscape level is useful for addressing food security and rural livelihood issues and in responding to the impacts of climate change and contributing to its mitigation.** A landscape is an area large enough to produce vital ecosystem services, but small enough to be managed by the people using the land that produces those services (FAO 2013). A landscape can comprise several ecosystems, human activities and institutions managing the landscape. The landscape level is the scale at which many ecosystem processes operate and at which interactions among agriculture, environment, and development objectives are mediated. It entails the integrated planning of land, agriculture, forests, and water at local, watershed, and regional scales to ensure synergies are properly captured.

83. **The landscape approach provides a framework for the better management of ecosystem services, such as agricultural productivity, carbon storage, fresh water cycling, biodiversity protection, and pollination.** It allows trade-offs to be explicitly quantified and addressed through negotiated solutions among various stakeholders (World Bank 2012). A multi-sector approach and coordination across sectors—such as agriculture, food security, water, forestry and planning sectors—will be required. Such collaboration is typically reflected in watershed or integrated catchment plans that include a range of interventions at both farm and catchment level to enhance the climate resilience and GHG mitigation of the farming systems through

FIGURE 4.18: TRADE-OFFS BETWEEN CSA PILLARS



Source: Modified from World Bank (2016a)

[21] West, P.C.; Gibbs, H.K.; Monfred, C.; Wagner, J.; Barford, C.C.; Carpenter, S.R.; Foley, J.A. Trading carbon for food: Global comparison of carbon stocks vs. crop yields on agricultural land. *Proc. Natl. Acad. Sci. USA* 2010, *107*, 19645–19648.

solutions that enhance water use efficiency and productivity, improve soil health, and increase crop productivity. Examples of landscape approaches include integrated watershed management, integrated crop-livestock management, agroforestry, improved rangeland management, sustainable forest management, ecosystem approaches, and sustainable landscape approaches (box 4.5).

84. **From a CSA perspective, the main objective of a landscape approach is to enhance the synergies between CSA's triple pillars, while sustaining**

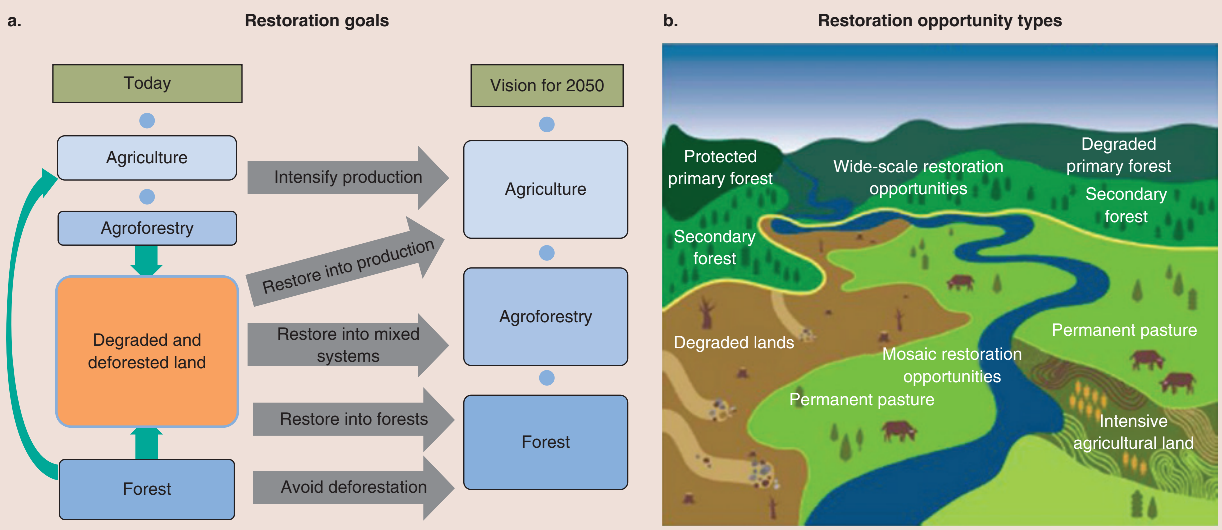
BOX 4.5: SUSTAINABLE LANDSCAPE APPROACH AND SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The Sustainable Landscape Approach (SLA) is a key bridge connecting agriculture, livestock, forestry, and fisheries with constraints of land, water, and other natural resources. SLA integrates spatial, ecological, and socio-economic approaches to manage land, water, and forest resources. It focuses not only on food security, but also on inclusive green growth in temporal and spatial dimensions. Management of various land-based ecosystem services is coordinated to prevent land fragmentation. The scaling up of landscape approaches requires knowledge management and institutional capacity and must be backed up by an enabling policy and market environment.

Unsustainable land management practices have resulted in severe land degradation. An estimated 40 percent of the world's agriculture lands are seriously degraded, leading to decreases in productivity, declining resilience to extreme climate events, such as droughts and floods, and increased greenhouse gas emissions. Forest lands have been converted primarily to croplands and grazing lands to satisfy the growing demand for goods.

The good news is that more than 2 billion hectares of the world's cleared and degraded forest lands offer opportunities for landscape restoration. This includes 700 million hectares in Africa, 400 million hectares in Asia, and 500 million hectares in Latin America. Therefore, degraded lands should be viewed as an opportunity for delivering multiple development and climate benefits as shown in the figure below.

FIGURE B4.5.1: OPPORTUNITIES FOR DEGRADED LANDS



Source: "Restoring degraded land for more productive and climate resilient development" (World Bank 2016)

Restoration of degraded lands not only offers increased productivity and income, while enhancing resilience to climate change for farmers but can also allow countries to target multiple SDGs: SDG 2, zero hunger; SDG 3, good health and well-being; SDG 6, clean water and sanitation; SDG 13, climate action; and SDG 15, life on land.

the ecosystem services provided by land. Landscape approaches seek to integrate sustainable management of ecosystems and natural resources with livelihood considerations, recognizing that landscapes are multifunctional, providing benefits and services for a wide range of ecosystem processes, species and social actors. Landscape approaches seek to understand the different elements and related interests in the landscape (e.g., water resources, agricultural production, biodiversity conservation and forest management) and their interdependencies. The main reason for applying landscape approaches is to move away from narrow sectoral approaches with uncoordinated and competing land uses, to integrated planning and management where the multiple interests of stakeholders are considered, synergies are identified, and trade-off among different uses is negotiated. A landscape level approach enhances field level productivity because it maintains ecosystems service and creates synergies between different production systems. It also increases adaptation by reducing weather, pest, and disease risk through land use diversity. Lastly, diversified land use systems incorporating forests, woodland, perennial crops, grasslands, and wetlands helps to reduce GHG emission and promote carbon sequestration. The Alternatives to Slash-and-Burn (ASB) program is an example of trade-off analyses and decision support tool for implementing the landscape approach (box 4.6).

BOX 4.6: THE ALTERNATIVE TO SLASH-AND-BURN LANDSCAPE APPROACH

The ASB program[22] is an example of a relatively well-tested landscape approach on eco-regions nested within the humid tropical broadleaf forest biome. The benchmark sites are in the Peruvian Amazon, the western Amazon of Brazil, an associated site in the eastern Amazon of Brazil, the Congo Basin of Cameroon, northern Thailand, and the islands of Sumatra in Indonesia and Mindanao in the Philippines. The approach incorporates a range of CSA technologies along gradients of land use intensity and the methodologies to assess and optimize synergies and tradeoffs. The basic goal of ASB is to identify and articulate combinations of policy, institutional, and technological options that can raise productivity and income of rural households without increasing deforestation, land degradation, or undermining essential environmental services. The ASB is built around two overarching issues—the global environmental effects of slash-and-burn and the technological and policy options to alleviate those effects. The program assumes that the development of agroforestry-based forms of intensified land use as an alternative to slash-and-burn can help alleviate poverty and improve human welfare. By identifying alternatives to slash-and-burn and providing options from which farmers can choose, the ASB program aims to provide benefits at a range of scales, from household to global level. Analysis of conditions of the various categories of ecosystems services associated with the different land use systems at the ASB benchmark sites provides a trade-off matrix (land use systems, global environmental concerns, smallholders' agronomic concerns, smallholders' socio-economic concerns, and institutional requirements) and the tradeoffs among them. It is a useful tool for multiple stakeholders, often with conflicting interests, in analyzing and negotiating the outcome of certain land-use changes. ASB results show that striking an equitable balance between the legitimate interests of development and equally legitimate global concerns over the environmental consequences of tropical deforestation can be challenging. Poverty reduction in most of the tropics depends on finding ways to raise productivity of labor and land through intensification of smallholder production systems. Although there may be opportunities to alleviate poverty while conserving tropical rainforests, it is naïve to expect that productivity increases necessarily slow forest conversion or improve the environment. Deforestation has no single cause but is the outcome of a complex web of factors whose mix varies greatly in time and space. Understanding the factors at work in a given situation is a crucial first step if policymakers are to introduce effective measures to curb deforestation and to do so in ways that reduce poverty.

[22] https://www.millenniumassessment.org/ma/ASB-MA_statusreport_ver5.0.pdf

4.12 Success stories: demonstrating impact of CSA technologies

85. **The growing momentum on Climate-Smart Agriculture in high-level decision-making spaces is being increasingly reflected in farmer's fields around the world.** There is growing demand in World Bank client countries for assistance in putting their food and agriculture sectors onto a more climate-smart path. There also is a hunger for practical, implementable knowledge on CSA. This has led the World Bank to recently produce a booklet showcasing CSA Success Stories across the continent (Hou et al. 2016). The stories indicate how countries have combated drought, raised productivity through climate-smart irrigation, improved coffee farming through public-private partnership, improved livestock productivity, better nutrition, animal husbandry and health, and created a more sustainable food system. These initiatives have all paid dividends in terms of boosting the livelihoods and resilience of smallholder farmers and cutting emissions. A few examples are discussed below.

West Africa Agricultural Productivity Program (WAAPP)

86. **The World Bank funded WAAPP is making agriculture more climate smart across 13 West African countries to ensure that the agriculture sector remains sustainable for future generations.** The project supports the adoption of stress-tolerant crops that increases yields, farmers' income and resilience to climate change. An assessment of the potential impacts of the adoption of Drought-Tolerant Maize for Africa (DTMA) indicated yield increases of 10 percent to 34 percent over non-drought-tolerant varieties and a cumulative economic benefit of about US$0.9 billion. The DTMA could assist more than 4 million people to escape poverty, in addition to improving the livelihoods of many millions more (Cooper et al. 2013).

87. **WAAPP's support to a new generation of local scientists and "national centers of specialization" or research centers focused on commodities that are a country's competitive advantage has helped develop climate-smart varieties of staple crops, such as rice (Mali), banana plantain (Cote d'Ivoire) and maize (Benin).** Collaboration with a network of cooperatives and extension workers is helping deliver these new varieties to farmers across West Africa. WAAPP has developed and distributed 160 climate-smart crop varieties; provided climate-smart technologies, such as post-harvest and food processing technologies; and trained farmers on climate-smart practices such as composting and agroforestry. Farmers also are getting access to technologies like more efficient water harvesting systems. WAAPP assistance has helped more than 7 million farmers and more than 4 million hectares of land be more productive, resilient, and lower GHG emissions. Productivity has increased by up to 150 percent. Food production has increased by more than 3 million tons, beneficiary incomes have grown by an average of 34 percent, the hunger period has been reduced by half, and staple food availability and nutrition standards have increased throughout West Africa.

Agroweather tools for adapting to climate change in East Africa

88. **In 2012, the World Bank and its partners launched a pilot project in Ethiopia and Kenya named Agroweather Tools for Adapting to Climate Change to determine how climate information services (CIS) can be used to improve the adaptation response of farmers (Braimoh et al. 2015).** The project aimed to improve farmers' access to relevant information on weather and climate, develop farm management capabilities in a context of climate change, raise awareness of the practical utility of agroweather information products, and improve extension services. While the national agricultural meteorology programs in both countries are limited, a number of international development agencies and non-government organizations (NGOs) are operating in both countries and have been promoting various CIS as components of more general initiatives to increase the resilience and adaptive capacity of smallholders in particular.

89. **In Kenya, the project enlisted 4,500 farmers in Embu County who were divided into four categories as per the crop of interest—tea, coffee, sorghum, and maize and beans (maize usually intercropped with beans).** In Ethiopia, the project recruited 1,700 farmers in Ada'a District and was divided into four categories as per the crop of interest—chickpea, lentil, teff, and wheat. In Kenya, the top four most prominent sources of agroweather information were extension agents, radio, newsletter/bulletin and cellphones, while in Ethiopia farmers most favored radio, cellphone, and bulletins. Low literacy rates make printed dissemination pathways problematic, especially for early warning systems in Ethiopia. Significant differences in agricultural outcomes were observed between beneficiaries and non-beneficiaries. The multiple sources of information used by farmers suggested the need for a strategy that employs a combination of modern and traditional information and communication technologies (ICTs). The information was likely to have more value if it was communicated through extension agents or contacts the farmers already know or trust. The beneficiaries of CIS indicated that the information provided improved use of farm resources, changed planting and harvesting practices, and was effectively used to prevent pest and disease attacks.

90. **The contrast between project participants and non-participants in both countries serves to validate the proof of concept the pilot employed—that smallholder farmers make more informed decisions when they have access to agroweather tools, both timely weather forecasts and seasonal advisories.** This advantage held consistently across the commodities, with dramatic differences in the timing of planting, fertilizer applications and harvesting. CIS enabled farmers to make appropriate decisions in their choice of varieties. It was highly useful in making and complementing recommendations on which farm inputs to use. It was used to good advantage by extension services and farmer organizations, resulting in higher rates of new varieties and improved practices. And despite the marked differences between participants and non-participants, the interest that CIS stimulated among other producers generated benefits that spilled over into the entire local farming community.

91. **Another major benefit of the CIS is the remarkable impact on farm income.** In Kenya, farmers with access to agroweather information recorded an income from maize of 9,402 shillings (Kes)

compared to 3,918 Kes for non-beneficiaries. The pattern of teff income is similar in Ethiopia where beneficiaries obtained an average income of 19,760 Birr compared to 17,878 Birr for non-beneficiaries. Access to agroweather information markedly improved the resilience of project beneficiaries. The impacts of drought were more pronounced on non-beneficiaries who were markedly less prepared to adapt to weather variability. Better farming decisions resulting from access to agroweather information led to lower variability in yield and income and less crop failure among the beneficiaries.

Carbon payment incentive for delivering CSA in Zambia

92. **Recent years have not been easy for smallholder farmers in Eastern Province of Zambia due to high weather variability.** Traditional farming practices, as well as lack of access to improved production technologies and affordable inputs, have resulted in crop production shortfalls. Farmers have pursued unsustainable agricultural practices to help them cope, which have spurred several landscape challenges including deforestation, soil erosion, nutrient depletion, and biodiversity loss. This led to the launch of the Community Markets for Conservation (COMACO) Landscape Project in the Eastern Province. The COMACO Project illustrates successful partnership in landscape management involving the private sector (COMACO), the Government of the Republic of Zambia, and the World Bank. The project covering 270,000 hectares is a model for rural development that uses inputs, technologies, and markets to help smallholders achieve food security and boost incomes, while conserving the natural resources they rely on. COMACO model's premise is that with the right incentives and training, smallholders will favor CSA practices over unsustainable traditional methods, especially if basic food and income needs are met. Through contract farming, COMACO offers above market prices for crops that are produced in compliance with sustainable soil, farming, and conservation agriculture practices.

93. **Farmers are recruited and organized into cooperatives by COMACO. They then receive training and inputs to implement CSA practices using the lead farmers extension approach.** CSA practices disseminated through the project include Agroforestry: planting crops in alleys of *Gliricidia*, a fertilizer tree that fixes nitrogen in soils; mulching and crop residue retention (no burning of biomass); crop rotation and diversification with legumes; and composting. Through contract farming arrangement, COMACO provides markets for crops produced by farmers. In addition, REDD+ activities are being implemented on more than 116,000 hectares of community forests. The project beneficiaries stretch across nine chiefdoms in the province. Land use plans are developed for communities and rules for forest conservation enforced. COMACO finances farmers' recruitment, training, activities monitoring, supervision and other implementation costs. The World Bank offers technical support in project preparation that include emissions reduction feasibility assessment, baseline preparation, and verification and purchase of emissions reduction was generated by the project through a BioCarbon Trust Fund (Payment for Results). There are no upfront investment costs.

94. **In 2017, 18,000 smallholder farmers and participating communities received over $800,000 in carbon payments from the BioCarbon Fund (https://www.biocarbonfund.org/)** for 228,000 tons of carbon dioxide equivalent emission reductions verified by international standards. The project provides evidence that climate mitigation and socioeconomic development can be simultaneously achieved through active participation of local communities and policy measures that generate tangible benefit to the communities. The Zambia Integrated Forest Landscape Program is scaling up this approach and expanding the beneficiary group to more than 250,000 smallholder households over the 14 districts in the Eastern Province with an expected carbon payment of up to US$30 million if net results on reducing deforestation are achieved. The ZIFLP will provide support to rural communities in the Eastern Province to allow them to better manage the resources of their landscapes to reduce deforestation and unsustainable agricultural expansion; enhance benefits they receive from forestry, agriculture, and wildlife; and reduce their vulnerability to climate change.

V.

Mainstreaming Resilience in CSA Projects

5.1 Building resilience capacity through CSA

95. **A major goal of the ACBP is to deliver on CSA at scale to increase the efficiency and resilience of food systems in Africa.** To determine how well the ACBP is contributing to resilience building, this report examines resilience consideration in CSA projects' design using the World Bank Resilience Monitoring & Evaluation (ReM&E) framework (World Bank 2017b). 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). Based on this definition, resilience building involves strengthening the following three specific capacities (OECD 2014; World Bank 2017c):

1) **Absorptive capacity.** The ability of people, assets, and systems to prepare for, mitigate, or prevent negative impacts of hazards so as to preserve and restore essential basic structures and functions; for example, through protection, robustness, preparedness, and/or recovery.

2) **Adaptive capacity.** The ability of people, assets, and systems to adjust, modify, or change characteristics and actions to moderate potential future impacts from hazards so as to continue to function without major qualitative changes; for example, through diversity, integration, and/or flexibility.

3) **Transformative capacity.** The ability to create a fundamentally new system to avoid negative impacts from hazards; for example, through system shift, livelihood diversification, or migration.

96. **Resilience building was analyzed at the activities level, that is, actions and interventions facilitated and financed by CSA operations.** Project activities were identified in the project documents and categorized under nine resilience concepts/approaches corresponding to absorptive, adaptive, and transformative capacities, namely protection, robustness, preparedness, recovery, diversity, flexibility, integration, system shift, and livelihood diversification (World Bank 2017b; table 5.1).

97. **Table 5.2 shows that 25 out of 43 project activities (58 percent) contribute to building adaptive capacity, followed by 26 percent that contribute to building absorptive capacity, while 16 percent intend to build transformative capacity.** The fact that developing adaptive capacity predominates project activities suggests that projects are incorporating incremental changes in their systems to adjust to, better manage, anticipate, and/or mitigate potential future impacts of climate and disaster risks.

98. **Figure 5.1 shows that promoting flexibility, for example, through provision of climate advisory services and weather insurance (30 percent), and diversifying farm operation, for instance, through intercropping, crop-livestock interactions, and use of stress-tolerant species (26 percent), are the major resilience concepts applied for building adaptive capacity in the CSA project portfolio.** Climate-resilient irrigation and flood control design and provision of better storage facilities to augment robustness (9 percent) and safety nets and forests protection (7 percent) are the major concepts applied for absorptive capacity, while building transformative capacity largely entails promoting resilience through system shift (17 percent) entailing market system interventions,

TABLE 5.1: RESILIENCE CAPACITIES, CONCEPTS, AND EXAMPLES OF PROJECT ACTIVITIES

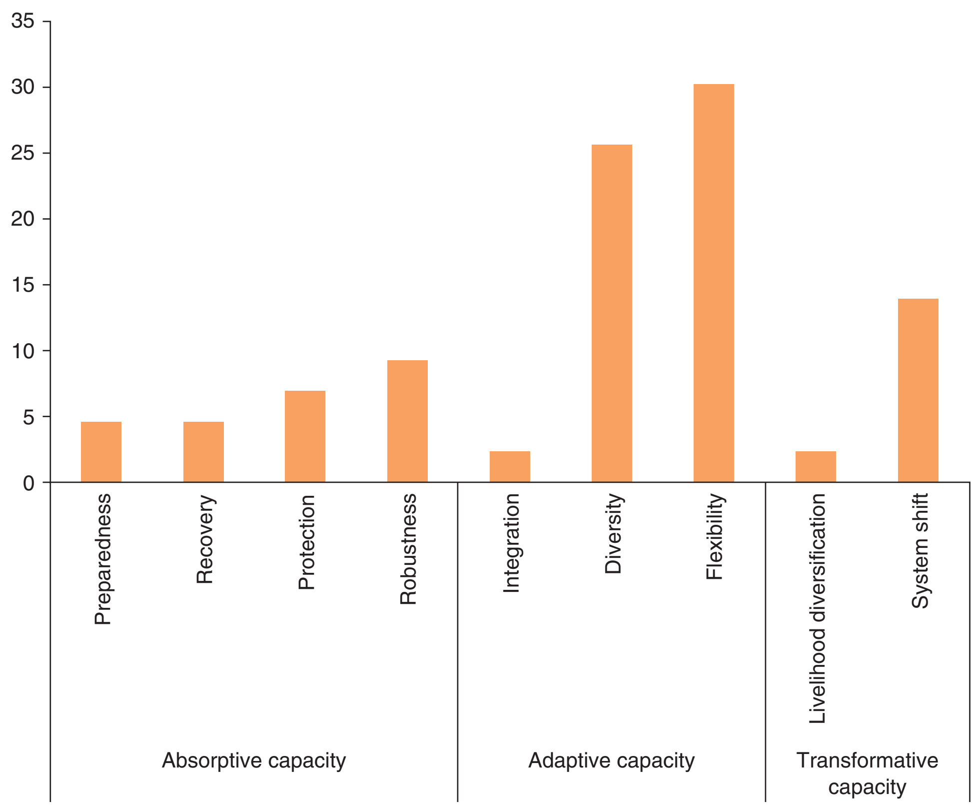
Resilience capacity	Concept	Example of project activities
Absorptive	Protection	Erosion protection Social protection system, including shock responsive safety nets Conservation of protected areas, such as forests and watersheds
	Robustness	Maintaining, upgrading or rehabilitating roads Climate-resilient irrigation design Climate-resilient flood control Better food storage facilities
	Preparedness	Contingency plans EWS development or strengthening disaster risk management (DRM) systems
	Recovery	Provision of emergency or relief food Rehabilitating degraded lands, soil salinity control, and soil acidity control
Adaptive	Diversity	Stress-tolerant varieties Intercropping, agroforestry to diversify farms Crop-livestock production Conservation agriculture (minimum/no tillage, crop rotation, mulching/crop residue management) ISFM (improved varieties; organic nutrients, such as manure, compost, crop residues; inorganic fertilizers) Micro-propagation, macro-propagation and establishment of communal nurseries for mass production Surveillance of pests and disease outbreak Integrated dairy production Agroforestry
	Flexibility	Post-harvest management Capturing biogas from anaerobic processes Micro-irrigation/AWD Water harvesting Provision of quality livestock inputs Weather index insurance Climate and weather-informed advisories Agroweather tools Financial inclusion Farmers training Market information system Research Extension services
	Integration	Institutional building, enhancing community institutions, enhancing water user associations, and establishing or promoting farmers' associations
Transformative	System shift	Shift to higher value agricultural production Exploring new markets for crops Agricultural commercialization Agricultural value chain development Warehouse receipt system
	Livelihood diversification	Alternative livelihoods, such as mushroom production, non-timber forest products extraction, and non-farm jobs such as handicraft, trading, and wage labor

Source: Authors

TABLE 5.2: RESILIENCE CAPACITIES DEVELOPED IN CSA PROJECTS

Capacity	No. of project activities	Proportion (%)
Absorptive	11	26
Adaptive	25	58
Transformative	7	16
Total	**43**	**100**

FIGURE 5.1: FREQUENCIES OF RESILIENCE CONCEPTS APPLIED IN THE CSA PROJECT PORTFOLIO (%)

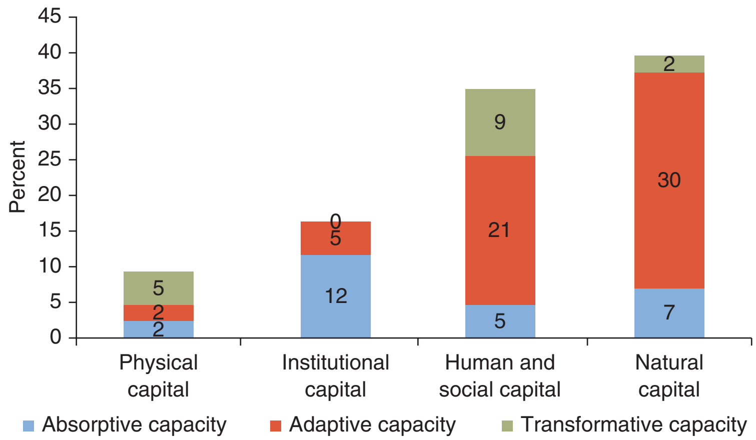


Source: Authors

such as agricultural commercialization, agricultural value chain development, and shift to higher value crop production.

99. **Resilience—assessed in terms of building absorptive, adaptive, and transformative capacities—can be achieved through access to or improvement of a range of livelihood resources (assets), namely social, human, physical, and natural capital (DFID 2000).** Figure 5.2 shows that the CSA portfolio mostly focuses on building natural capital (39 percent of project activities) and building human and social capital (35 percent). Activities that build these types of capital mainly contribute to developing adaptive capacity (51 percent). Soils and vegetation are the basic resource and the central elements of most CSA approaches. Interventions such as ISFM, agroforestry, and CA have the major goal of building natural capital by increasing soil health and reducing land degradation. Efforts to build human capital through training and skills development will help address capacity gap, a critical barrier to the adoption of CSA technologies.

FIGURE 5.2: DISTRIBUTION OF PROJECT ACTIVITIES ACROSS TYPES OF CAPITAL AND CAPACITIES STRENGTHENED



Source: Authors

100. **Only 17 percent of the portfolio is devoted to building institutional capital through developing absorptive and adaptive capacity.** There is a need to invest more in institutional capital through policy development and enhanced private sector participation. Market system approach to climate resilience seeks to connect the poor to markets and use the private sector to encourage poverty reduction and economic growth through a range of interventions (box 5.1).

101. **One such project addressing institutional capital development is the Congo Commercial Agriculture Project (box 5.2).** In addition to improving market access for smallholder farmers, the project supports the development of policies for improving the legal and regulatory frameworks for commercial agriculture. It fosters a public-private partnership and identifies the needed reforms for improving the enabling environment for commercial agriculture.

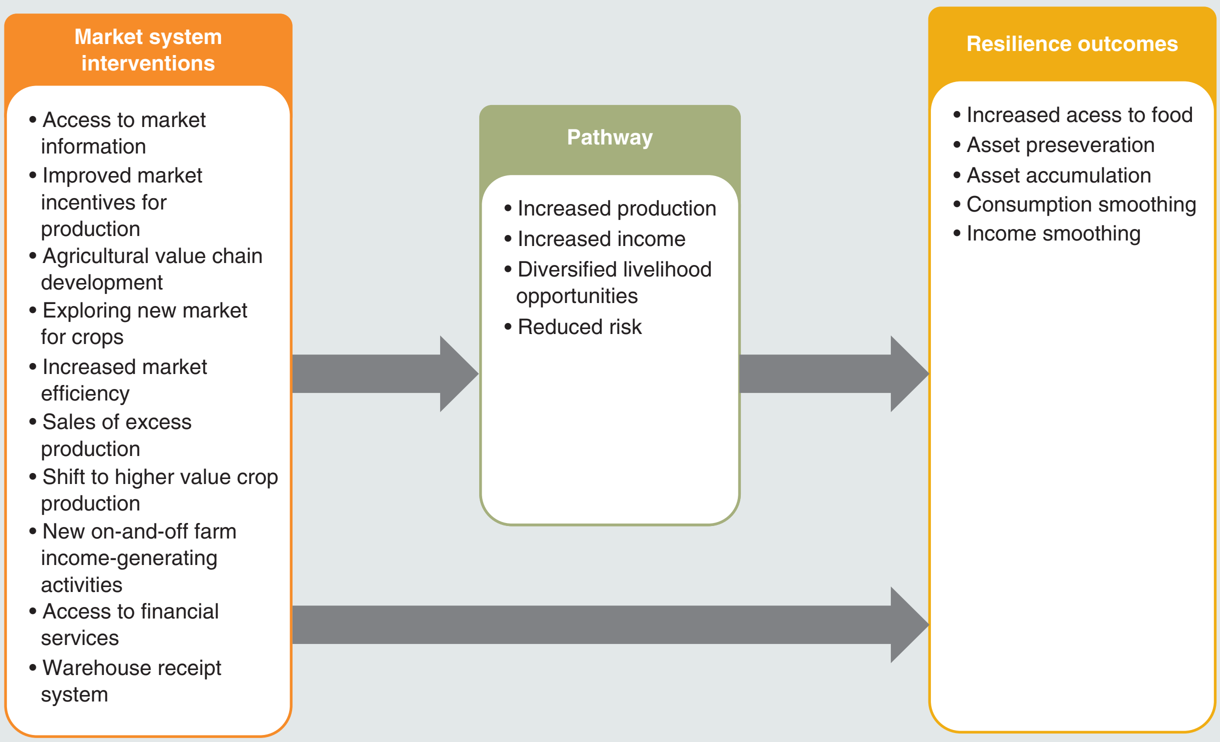
5.2 Pathways for building resilience to climate change

102. **In this section, we provide examples (pathways) of how the CSA projects are increasing the stocks of various forms of capital to build resilience to climate change.** Two projects are used to illustrate building absorptive capacity. In the first, the Mozambique Emergency Resilient Recovery Project strengthen physical capital by rehabilitating existing roads and constructing new roads to improve farmers' access to farms and markets. The project also provides climate-resilient flood control system to reduce flood risks (figure 5.3).

BOX 5.1: MARKET SYSTEM INTERVENTIONS CAN HELP BUILD RESILIENCE TO CLIMATE CHANGE

A market systems approach seeks to connect the poor to markets and use the private sector to encourage poverty reduction and economic growth. 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 B5.1.1 RELATIONSHIP BETWEEN MARKET SYSTEM INTERVENTIONS AND RESILIENCE OUTCOMES



Source: Modified from Kuhl (2018)

BOX 5.2: CONGO COMMERCIAL AGRICULTURE PROJECT ON COMMERCIALIZATION, POLICY DEVELOPMENT, PRIVATE SECTOR ENGAGEMENT, AND MARKET ACCESS

The Congo Commercial Agriculture Project aims to improve productivity of farmers and market access for producer groups including micro, small, and medium agribusiness enterprises. The project promotes farmers' access to market, including the supply of high-quality value-added products; improves enabling business environment through legislation; and creates a framework for public-private dialogue (PPD) to develop the agricultural sector.

The project improves the legal and regulatory framework for commercial agriculture by (a) establishing and financing platforms for PPD on commercial agriculture; (b) providing TA to draft the identified legislation and regulations; (c) supporting policy advocacy with parliamentarians; and (d) conducting sensitization, dissemination, and training activities for ministries and public institutions, producer groups, micro, small, and medium agribusiness enterprises, and other private sector actors.

103. **In the second example, the Malawi Drought Recovery and Resilience Project introduced soil erosion protection measure, conservation of protected areas, and strengthened safety nets systems (social protection) to strengthen physical and natural capital (figure 5.4).**

104. **The West Africa Agricultural Productivity Program develops adaptive capacity by augmenting human, social, and institutional capital through strengthening research capacity, and enhancing the capacity of community institutions (farmers' associations) promoting the adoption of CSA (figure 5.5).**

105. **An example of a project developing transformative capacity is the Nigeria Agriculture Production and Industrialization project that promotes alternative livelihoods such as non-timber forest products extraction, and non-farm jobs (such as handicraft, trading, and wage labor).** It also promotes a shift from subsistence to contract farming among farming communities, strengthening both human and social capital, and institutional capital (figure 5.6).

106. **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. The Niger Community Action Project develops both absorptive and adaptive capacities through productive diversification and development of farmers' associations that augment natural and institutional capitals (figure 5.7).

FIGURE 5.3: DEVELOPING ABSORPTIVE CAPACITY THROUGH ROBUSTNESS OF PHYSICAL CAPITAL

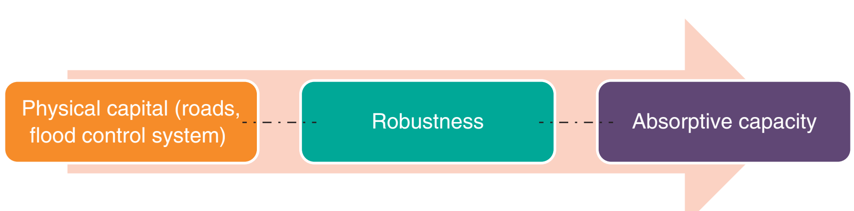


FIGURE 5.4: DEVELOPING ABSORPTIVE CAPACITY THROUGH PROTECTION OF LIVELIHOOD RESOURCES

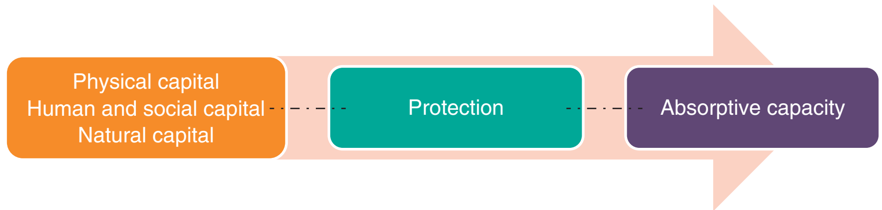


FIGURE 5.5: DEVELOPING ADAPTIVE CAPACITY BY ENHANCING THE EFFICIENCY OF HUMAN CAPITAL AND COORDINATION OF LOCAL INSTITUTIONS

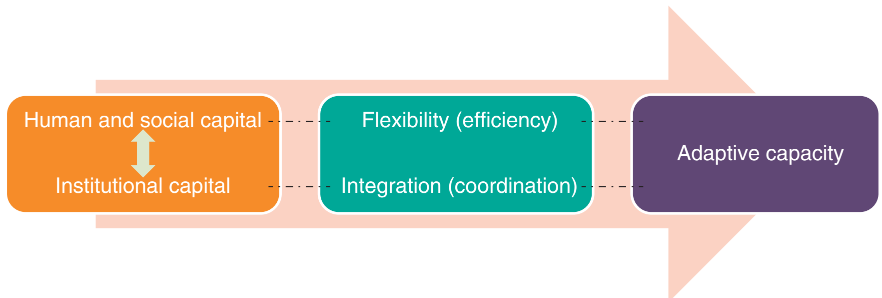


FIGURE 5.6: DEVELOPING TRANSFORMATIVE CAPACITY THROUGH LIVELIHOOD DIVERSIFICATION AND CONTRACT FARMING

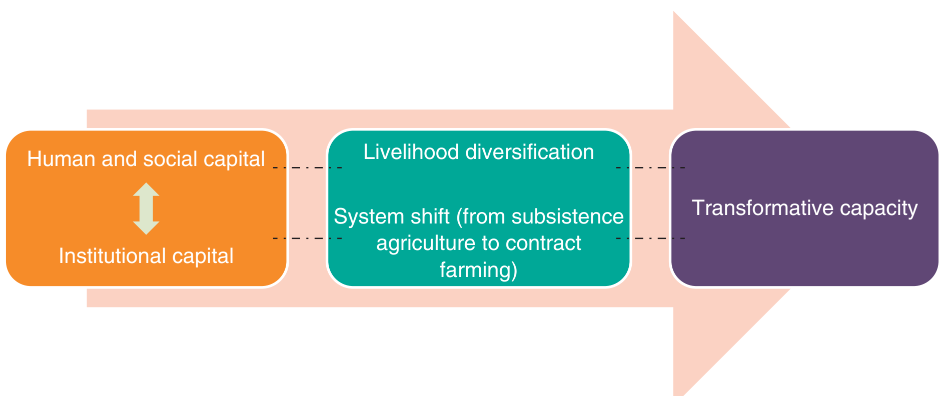


FIGURE 5.7: DEVELOPING ABSORPTIVE AND ADAPTIVE CAPACITIES THROUGH PRODUCTIVE DIVERSIFICATION AND INSTITUTIONAL STRENGTHENING

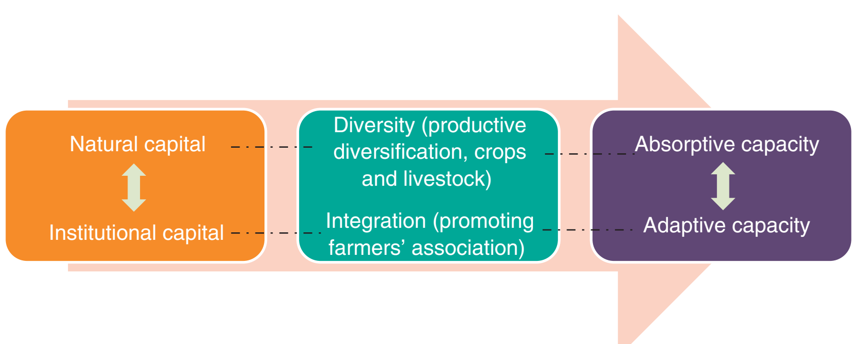


FIGURE 5.8: DEVELOPING ADAPTIVE AND TRANSFORMATIVE CAPACITIES THROUGH CROP-LIVESTOCK INTEGRATION AND COMMERCIALIZATION

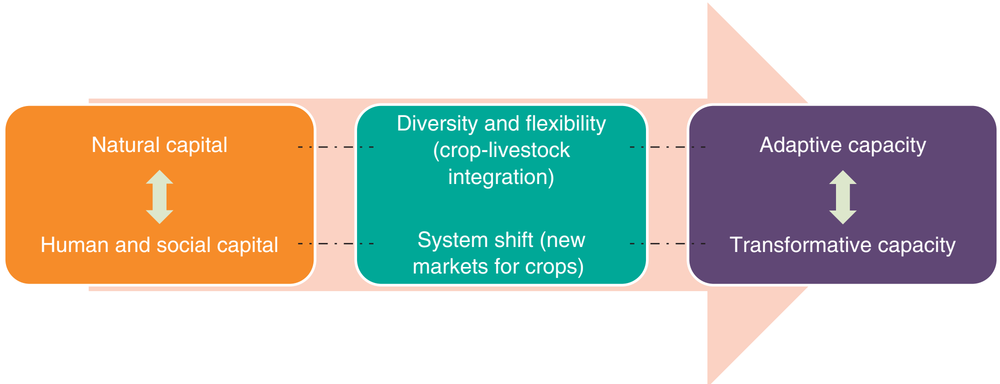


FIGURE 5.9: DEVELOPING ABSORPTIVE, ADAPTIVE, AND TRANSFORMATIVE CAPACITIES THROUGH EARLY WARNING SYSTEMS, STRESS TOLERANT VARIETIES, COMMERCIALIZATION, AND ALTERNATIVE LIVELIHOODS

107. **The Burundi Agro-Pastoral Productivity and Markets Development Project develops both adaptive and transformative capacities through crop-livestock integration and agricultural commercialization.** These practices strengthen natural, human, and social capital (figure 5.8).

108. **Kenya Climate-Smart Agriculture Project develops absorptive, adaptive, and transformative capacities through a range of interventions.** Integrated agroweather and market information systems are developed to enable farmers to prepare and respond to weather variability and market opportunities. The project also promotes the adoption of stress-tolerant crops and crop-livestock integration in the farming systems. In addition, it focuses on selected agricultural, livestock, and fisheries commodities for value addition and links to markets. Livelihood diversification interventions—such as animal husbandry, beekeeping, and adding value to animal products—are specially geared toward female participants. These measures help to strengthen a range of livelihood resources (figure 5.9).

109. **Given the intensity, frequency, and pace of climate change and the extreme vulnerability of African agriculture, resilience building needs to also include more transformational responses.** Such transformational interventions will need to support deep, systemic, and sustainable change with the potential for large-scale impact across the region (World Bank 2016b). The mechanisms for bringing about such transformational change are discussed in the last chapter.

VI.

Opportunities for Future Engagements

110. **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.

111. **This report reveals progress in mobilizing resources for CSA in Africa.** It also indicates substantial alignment of the World Bank's CSA portfolio with Africa's NDC priorities. As an implementing partner of the NDC Partnership, the World Bank continues to enhance cooperation so that countries have access to the technical knowledge and financial support they need to achieve large-scale climate and sustainable development related targets as quickly and effectively as possible. The World Bank also continues to support the Adaptation of African Agriculture to Climate Change (AAA),[23] an initiative of the Moroccan Government with the aim of advocating for increased funding for agricultural adaptation and facilitating access to TA and financing for Africa.

112. **Two sets of recommendations are presented to enhance efforts to scale up CSA for transformational change in Africa.**

Recommendation 1: Provide TA and capacity development for climate-smart investment

113. **Large-scale systematic investment is needed for CSA to be scaled out, but there is still the need for substantial TA in some countries to develop programs that attract direct co-financing from governments, development agencies, and the private sector.** TA can also be instrumental in indirectly mobilizing finance, by supporting the creation of policy environments and markets that are conducive to climate-resilient and low-carbon development, in addition to generating the evidence-based climate-smart approaches. Five key TA activities have been identified for transformative scaling up of CSA in Africa.

1) **Develop CSA country profiles.** CSA profiles provide concise information about climate-agriculture interactions; promising CSA technologies; adoption constraints; and policy, institutional, and financial enablers of CSA in a country. They help in developing the baseline for initiating discussion both nationally and globally, about entry points for investing in CSA at scale. CSA profiles have been produced or are about to be completed for only 10 countries in Africa, indicating a need to expand the coverage.

2) **Develop CSA investment plans.** The objective of the CSA investment plan is to identify and prioritize key policy actions, investments, and knowledge gaps. It will provide a deeper understanding of climate challenges facing the agricultural sector and interdependencies with other sectors to enable policy makers take forward-looking decisions for the development of the agriculture sector. The investment plan builds on ongoing stakeholder processes, identifies and fills remaining knowledge gaps, and supports the identification of current and future investment priorities by providing a framework for climate proofing and resource coordination, leading to robust investment strategies and policies with resilience and mitigation goals.

[23] See http://www.aaainitiative.org/initiative.

3) **Strengthen MRV systems for NDC.** MRV enables countries to track and report on the implementation and impacts of climate actions (mitigation and adaptation) and the finance used to support these actions. A major challenge when implementing NDCs is the requirement for MRV in ways that are consistent, transparent, comparable, complete, and accurate. Putting in place robust MRV systems consistent with national circumstances and development priorities requires innovative thinking. It needs technical guidance and extensive support for capacity development. Major activities that countries can take to develop MRV systems for their NDC include review of current MRV activities with the aim of identifying additional MRV requirements; establishment of institutional arrangements and coordination of MRV activities; assessment of data gaps and how existing systems can be extended to address the gaps; design of the system and establishment of data management process; and building of MRV capacity and improvement of the system over time.

4) **Promote knowledge sharing, learning, and capacity enhancement.** The importance of offering capacity enhancement and business incubators that provide mentoring in digital solutions should be highlighted as part of the CSA ecosystem. For example, integrating the relevant country and/or sub-regional members of the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)—a consortium of 85 African universities operating within 35 countries spanning the African continent—will be beneficial for CSA adoption and implementation. The World Bank is currently involved in the development of a regional project to empower and strengthen the RUFORUM consortium and partnerships to provide the human resources needed to accelerate agri-food systems transformation in Africa.

5) **Build capacity to access climate finance.** Smallholder farmers and small and medium enterprises (SMEs) face numerous constraints to access adequate and sufficient finance, and financial institutions usually avoid lending

to the agriculture sector due to perceived high risks and high transaction costs, among other factors. Blending climate finance with traditional agriculture finance can help address some of these challenges and attract new domestic and international sources of private capital to accelerate investments at scale in the agriculture sector. Climate finance refers to the flows of capital from both public and private sources that support and finance climate-smart investments and aim to achieve climate change adaptation and mitigation objectives (Sadler et al. 2016). Climate finance can act as a catalyst to (a) unlock additional sources of finance, specifically private capital; (b) tighten the links between financial institutions and smallholder farmers and agriculture SMEs; and (c) provide TA to build the capacities of players in the financial ecosystem (box 6.1). Africa faces a finance gap in the agriculture sector with low capacity to access climate finance. Critical areas that need capacity development include identifying funding gaps and needs; assessing public and private financing options; developing climate-smart investment plans, a project pipeline, and financing propositions; and developing financially viable opportunities for effective private sector engagement.

- The World Bank Group is working to help its client countries leverage the private sector in ways that optimize the use of scarce public resources. The Maximizing Finance in Development (MFD) approach is rooted in the Addis Ababa Agenda for Action, a global agenda to mobilize additional resources to achieve ambitious development goals. The MFD approach is focused on deploying concessional funds strategically to crowd in other financing sources, noting that while the largest supply of development resources remains domestic public spending, the greatest potential for expansion lies with private finance and the engagement of private business in the development process. As shown in figure 6.1, the MFD addresses what the private actors are currently doing, what they are not doing, understanding why, and confronting the policy distortions and lack of conducive enabling environment that hinder private sector responses (World Bank 2018).

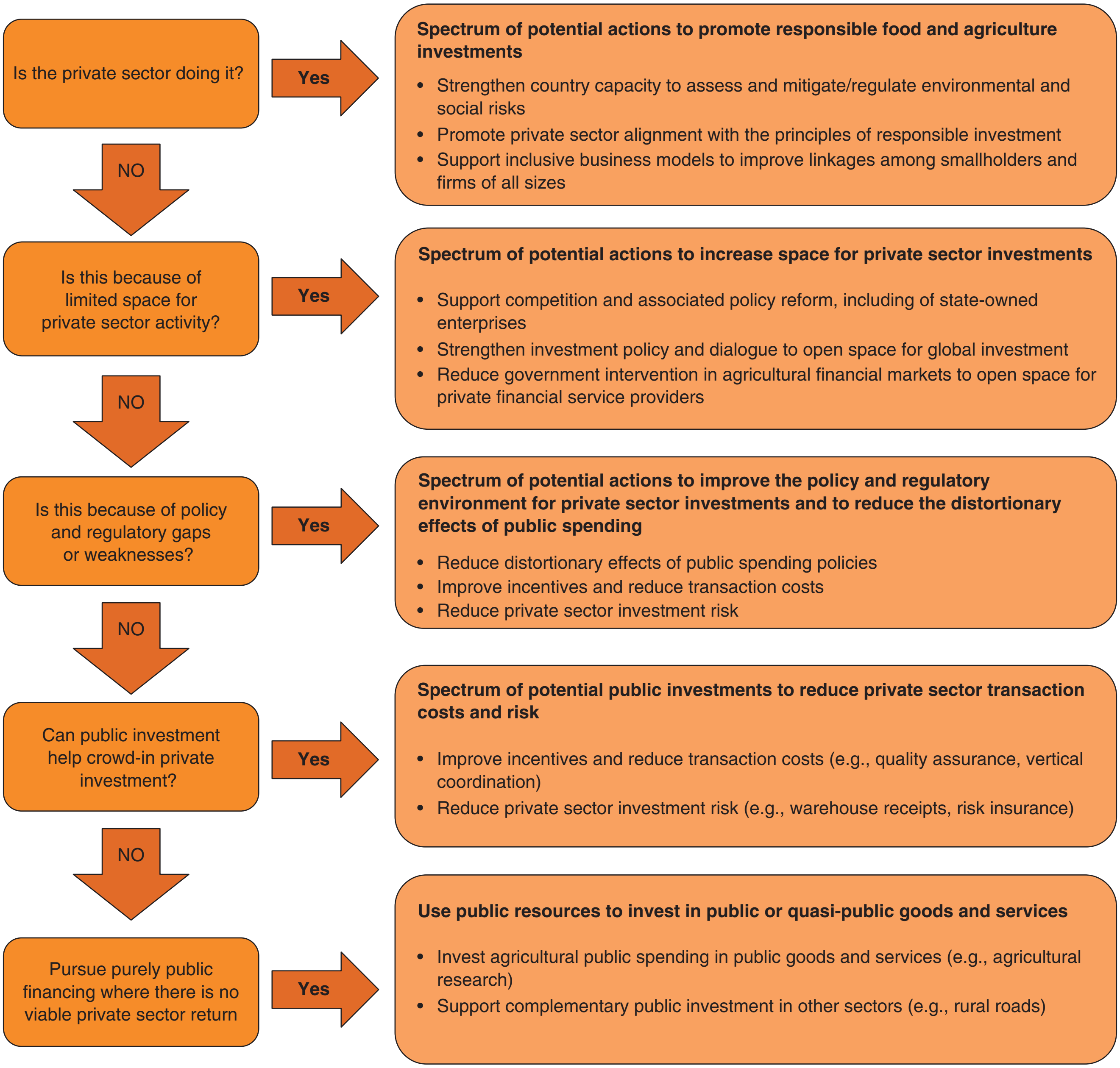
Recommendation 2: Accelerate the scaling up of CSA technologies and practices

114. **Agriculture in Africa can offer a pathway to economic development and inclusive growth.** More than any other sector in developing countries, growth in the agricultural sector is associated with poverty reduction. The growth in GDP that takes place in agriculture is at least twice as effective in reducing poverty as the growth that takes place in other sectors, and its significance to poverty rates increases roughly in proportion to the size of its role

BOX 6.1: INNOVATIVE FINANCE FOR CSA IMPLEMENTATION

The mainstreaming of climate-smart technologies and practices in agriculture in Kenya was promoted by UKAID through the Finance Innovation for Climate Change Fund (FICCF). The fund works by investing microfinance institutions (MFIs) partnering with agribusinesses and smallholder farmers to adopt a range of tools to de-risk production and build resilience to climate change. Repayable grants were provided to four MFIs for on-lending to farmers and agribusiness aggregators to invest in climate-smart commodities, technologies, and practices. Each MFI partnered with farmer aggregators, technical service providers, and insurance companies to contract farmers to produce selected commodities for identified and linked markets. Through matching grants and partnership facilitated by the FICCF, MFIs have learned the importance of climate information services for improving productivity and resilience. Greater productivity and the farm level translated to more ability to borrow and invest, while the MFIs secured additional funding for capacity development and scaling up. FICCF catalyzed a switch to more drought-resistant and early-maturing varieties. Herd size reduced while increasing milk yield per herd. Dairy farmers also gained knowledge on fodder-conservation techniques, while hybrid insurance with a weather index and multi-peril cover tested with 156 sorghum farmers resulted in 35 percent of the farmers receiving a payout.

FIGURE 6.1: MAXIMIZING FINANCE FOR DEVELOPMENT IN AGRICULTURE



Source: World Bank (2018)

in the larger economy. With the right policies and investments, agriculture could unlock an extra US$1 trillion in rural growth in addition to generating more than 21 million jobs in Africa by 2030 (Business and Sustainable Development Commission 2016; World Bank 2013b).

115. **To realize these opportunities, agriculture needs to be transformed by shifting the food system onto a climate-smart pathway.** This shift will transform the entire food system, with major impacts throughout the entire value chain (table 6.1).

116. **While the current CSA portfolio already has some elements of the ideas embodied in table 5.2, dedicated facilities for agricultural innovation and technology development will be required.** Regional projects with emphasis on innovation and technology development, such as Agricultural Productivity Program for Southern Africa (APPSA),

TABLE 6.1: A MENU OF SOME SHIFTS REQUIRED FOR TRANSFORMING AFRICA'S FOOD SYSTEM

Value chain area	From	To
Inputs	Basic cross-breeding	Precision phenotyping to introduce improvement into crops and livestock
	Industrial fertilizers	Microbial fertilizers
	Chemical pest control	Integrated Pest Management
	Limited or no public-private collaboration	New public-private partnership focused on adapting technologies to local conditions
Production	Agricultural extensification leading to deforestation	Deforestation-free commodities through climate-smart approaches (for example, CA and holistic grazing)
	Forest degradation through unsustainable farming practices	Agroforestry, afforestation, and reforestation; reduced-impact logging; alternative livelihoods; and forest tenure and rights
	Low-data traditional farming	Digital agriculture, big data analytics, and precision agriculture
	Limited market access for smallholders	Improved market access through contract farming, productive alliance, and other partnership models
	Low-water efficiency agriculture	Micro-irrigation techniques and AWD in rice fields
	Water, energy, and land intensive products (for example, beef)	Focus on selecting species with lower environmental footprint
	Limited monitoring of animal welfare	Animal health monitoring and diagnostics
Food processing	Thermal processing of food leading to quality changes in foods, such as the destruction of vitamins, modifications to food texture and color, and the development of off-flavors	Improved food processing using high hydrostatic pressure technology rendering harmful microorganisms inactive without detrimentally affecting the color, flavor, or nutritional value, thus improving the overall quality of foods
	Unfortified staple crops	Biofortification to increase the density of vitamins and minerals in a crop through plant breeding, transgenic techniques, or agronomic practices
Logistics	Limited data storage systems	Dynamic supply chain management through cloud computing
	Limited traceability	Fully traceable product systems
Retail and disposal	Limited consumer differentiation for products	Sustainably sourced and fair-trade products
	Low focus on food safety	Food safety as business opportunity
	High levels of food waste	Composting and energy capture

West Africa Agricultural Transformation Project (WAATP), and the East and Central Africa Agricultural Transformation Project (ECAAT) have a role to play in this regard. The focus should be on developing transformational solutions across the value chain and accelerating the adoption of the technologies.

117. **There also is the need to leverage the big data and geospatial capabilities of the Agricultural Intelligence Observatory (Ag Observatory) of the World Bank's Agriculture Global Practice in targeting climate-smart interventions in existing and pipeline projects.** The Ag Observatory is a tool for near real-time identification and tracking of climate events that can trigger food insecurity, thereby facilitating early warning and proactive response actions. The Ag Observatory comprises high resolution agrometeorological data for both analytical and operational programs. It integrates currently available public domain agriculture

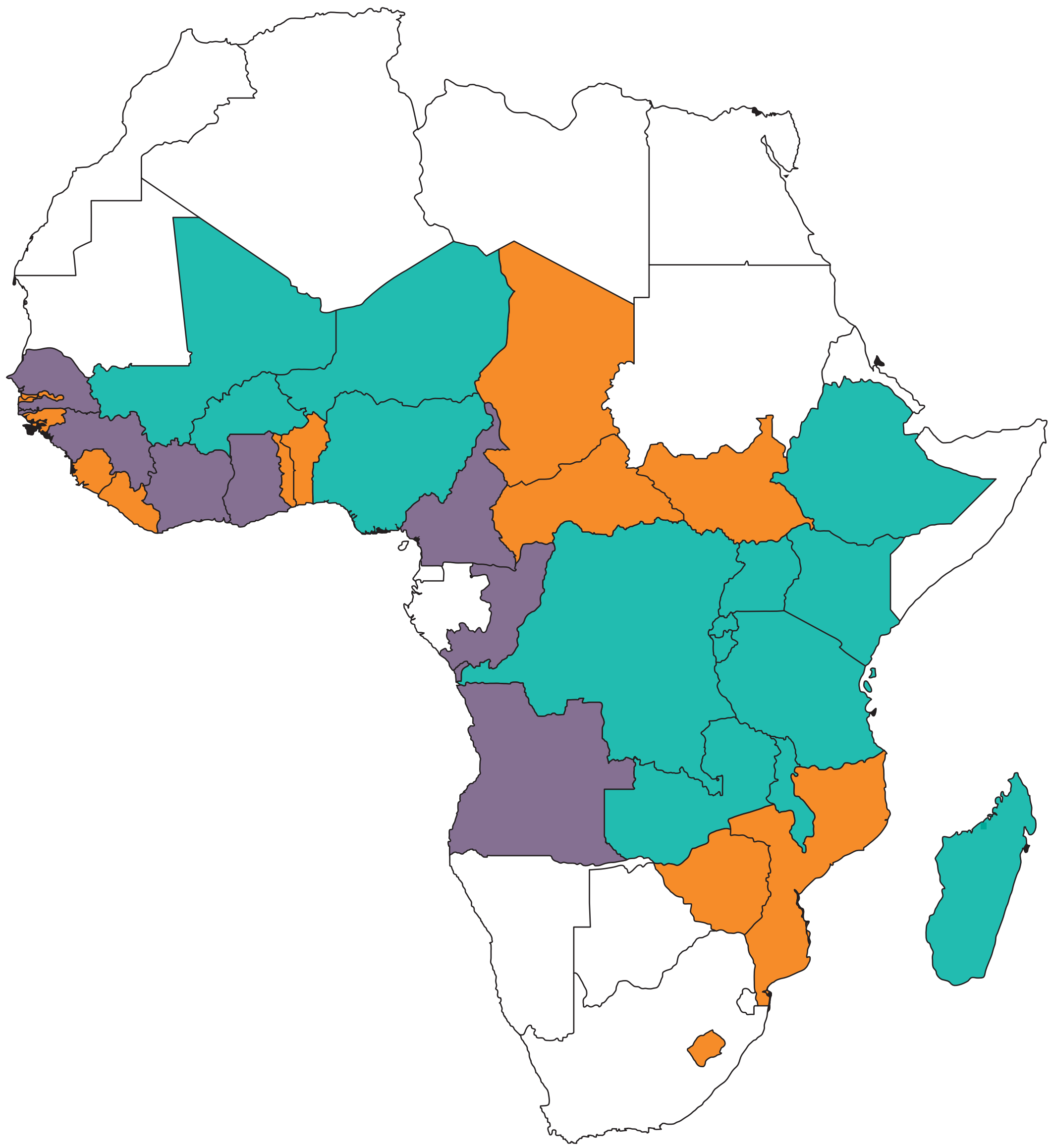
monitoring databases with private sector, open access, high resolution (9 km by 9 km) weather data coupled with local crop calendars and crop models. The integrated platform delivers agriculturally relevant information based on more than 1.5 million virtual weather stations distributed across the earth's agricultural land and updated 4 times daily. The Ag Observatory and component data platforms will assist countries in detecting early warning of farming system shocks, undertake famine threshold analyses, and initiate proactive response measures.

118. **Scaling up and replicating effective approaches and innovations could be based on criteria, such as climate vulnerability, the number of rural poor, poverty rates, and prevalence of under-nourishment.** In figure 6.2, countries are classified into three groups. The first group comprises countries with large numbers of rural poor and/or high rates of poverty and hunger, where there are larger ongoing World Bank agriculture programs. The second group entails countries with high rates of poverty and hunger, but where the World Bank has smaller or no agriculture programs. The last group includes countries where although the number of rural poor and poverty and hunger rates may not be the highest in the region, there is strong government commitment and, in some cases, larger ongoing agriculture programs.

119. **Finally, effective scaling up will require crowding in investment by increasing the space for private sector activity in agricultural markets, improving policy and regulatory environment and support services needed for successful agricultural value chains, leveraging public finance to improve private incentives, and managing private investment risks.**[24] Some examples of private sector investment include scaling up new technologies for agricultural transformation and developing innovative financing models for actors in the agricultural value chain.

[24] World Bank (2018). Future of food: Maximizing Finance for Development in Agricultural Value Chains. Washington, DC.

FIGURE 6.2: AGRICULTURE INVESTMENTS NEEDS ACROSS SUB-SAHARAN AFRICA



Group 1: High need, larger program–scale-up
Burkina Faso,[1] Burundi,[1,2] DRC,[1,2] Ethiopia,[1] Kenya,[1] Madagascar,[1,2,3] Malawi,[1,2] Mali,[1,2] Niger,[1,2] Nigeria,[1,2] Rwanda,[1,2,3] Tanzania,[1,2,3] Uganda,[1,3] Zambia[1,2,3]
Group 2: High need, smaller program–scale-up /reengagement
Benin,[2] Central Africa Republic,[2,3] Chad,[3] Gambia,[2] Guinea-Bissau,[2] Lesotho,[2] Liberia,[3] Mozambique,[1,2] Sierra Leone,[2,3] South Sudan,[1] Togo,[2] Zimbabwe[3]
Group 3: Other opportunities: Government commitment + some larger programs
Angola, Cameroon, Republic of Congo, Cote d'Ivoire, Ghana, Guinea, Senegal

[1]**Numbers of rural poor**. Nigeria, DRC, Ethiopia, Tanzania, Mozambique, Madagascar, Kenya, Uganda, Malawi, Niger, Burundi, Burkina Faso, Rwanda, Zambia, Mali, South Sudan account for most of the **rural poor** in Sub-Saharan Africa.

[2]**Poverty rates** (≥ 45%). Madagascar, DRC, Burundi, Malawi, Mozambique have the highest poverty rates.

[3]**Prevalence of undernourishment (hunger)** (>30%). Central African Republic, Zambia, Zimbabwe, Liberia, Madagascar have the highest rates of hunger.

Source: World Bank Senior Leadership Retreat Presentation, February 2018

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