

## **POLICY BRIEF**

## Technology needs for climate adaptation in agriculture: Evidence from Africa



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ISBN: 978-1-77933-272-1

EAN: 9781779332721

## Abstract

The adoption of Information and Communication Technology (ICT) plays a pivotal role in driving innovation to combat climate change in African agriculture. This policy brief underscores key factors influencing ICT adoption in agriculture, with a special emphasis on affordability, cost-effectiveness, and clear economic benefits. Access to digital farming solutions and ICT tools is rapidly spreading across the continent, particularly in providing farmers with essential weather information, market access, and improved agricultural practices. Despite these promising developments, significant challenges such as high data costs, limited digital literacy, and gender-based digital disparities must be addressed to ensure inclusivity in technological access. Furthermore, the knowledge product demonstrates the critical role of climate-resilient crop varieties and adaptable livestock breeds in agricultural technological innovation. This includes drought-tolerant, heat-resistant, and diseaseresistant crops, as well as livestock breeds suited for changing environmental conditions. Water management and irrigation technologies, such as precision agriculture and data analytics, are critical to optimizing resource use, increasing efficiency, and empowering women in agriculture. This document emphasizes the importance of ICT in closing technological gaps, improving weather monitoring, promoting resilient crops and livestock, and fostering sustainable practices across African agricultural systems. A gender-responsive approach to technological innovation is essential for ensuring equitable participation and closing existing gaps. Finally, the knowledge product emphasizes the importance of policy support, capacity development, and public-private partnerships in effectively integrating ICT into agriculture. By harnessing the potential of ICT while prioritizing gender-responsive solutions, Africa can successfully adapt to climate change, empower its farming communities, foster sustainable development, unlock economic opportunities, provide access to vital information, and scale up adaptation efforts. Ultimately, technological innovation through ICT is critical to building climate resilience and securing a prosperous and sustainable future for Africa.

## **Contents**

| 1. Introduction1  |
|---|
| 1.1 Why technological innovation is key to climate change adaptation in Africa? |
| 1.2 Technology Needs/Gaps for Climate Adaptation in African Agriculture4        |
| 1.2.1 Improved Weather Monitoring and Forecasting Systems5                      |
| 1.2.2 Climate-Resilient Crop Varieties and Livestock Breeds8                    |
| 1.2.3 Water Management and Irrigation Technologies9                             |
| 1.2.4 Sustainable Soil Management and Conservation Practices                    |
| 2. Enabling Factors for Technology Adoption12                                   |
| 2.1 Affordability and cost-effectiveness12                                      |
| 2.2 Policy and Governance Frameworks13  |
| 2.3 Capacity Development  |
| 2.4 Access to infrastructure  |
| 2.5 Public-Private Partnerships and Innovation Hubs15                           |
| 3. Case Studies and Success Stories/Innovations16                               |
| 4. Conclusion   |
| 5. References   |

## **1. Introduction**

The agricultural sector plays a crucial role in addressing climate change by reducing emissions (estimated at 12-19 per cent of global emissions), improving resource efficiency, and enhancing climate resilience. Climate sensitive agricultural practices such the use organic fertilizers, conservation farming, and agroforestry are key to reducing the carbon emissions, however, certain practices within the sector, such as deforestation for agricultural purposes and intensive use of inputs such as fertilizer and water, contribute to climate change. These activities emit greenhouse gases and may result in soil erosion and decreased carbon storage. Methane emissions from livestock production contribute to greenhouse gase emissions. Inadequate agricultural waste management also exacerbates emissions.



According to the Intergovernmental Panel on Climate Change (IPCC), temperatures in Africa will continue to rise significantly in the coming decades. The average temperature rise is expected to exceed the global average, resulting in heatwaves and extended periods of extreme heat. In addition to these temperature increases, precipitation patterns across Africa are expected to change. While some areas may experience increased rainfall and flooding risk, others may experience decreased precipitation, resulting in droughts and water scarcity<sup>[1]</sup>, According to the Intergovernmental Panel on Climate Change (IPCC) a reduction in precipitation is likely over North Africa and the south-western parts of South Africa by the end of the century<sup>[2]</sup>.

Extreme weather events such as cyclones, hurricanes, and storms are likely to become more frequent and intense in Africa. These occurrences have the potential to cause widespread damage to infrastructure, agriculture, and human settlements. Climate change is also threatening African ecosystems and biodiversity. The IPCC projections show potential ecosystem shifts, biodiversity loss, and increased risks to vulnerable species and habitats. Climate change is expected to have an impact on crop yields, livestock productivity, and overall food security in the agriculture sector [3]-[5]According to the IPCC, certain regions may experience decreased agricultural productivity, increased vulnerability to pests and diseases, and changes in crop growing seasons.

Changing climate conditions are directly affecting smallholder farmers, who have the least capacity to cope, through the prevalence and distribution of pests and diseases, posing risks to crop and livestock health. Small holder farmers are struggling with increased pest infestations, crop damage, and reduced productivity if adequate pest management strategies are not in place. While the different regions in Africa face climate-related challenges, the intensities of these risks can vary. Factors like geographical location, proximity to water bodies, elevation, and local climate patterns contribute to the distinct vulnerabilities faced by farmers in different parts of the African continent <sup>[6]</sup>.

Climate change exacerbates water scarcity and reduces forage availability, leading to challenges in livestock management and productivity on the African continent. This can result in decreased livestock body condition, reproduction rates, and milk production. In addition, the changing climatic conditions can create favorable environments for the emergence and spread of livestock diseases. This puts animal health at risk and can lead to livestock losses, affecting livelihoods and food security. Altered rainfall patterns and vegetation shifts can disrupt traditional grazing patterns. This can result in conflicts over grazing lands and force pastoralist communities, where women often play vital roles, such as crop farming, to adapt their livelihood strategies.

Increased marginalization of women, reinforcement of gender inequalities, gender norms, and power dynamics are some of the gender impacts of climate change in Africa's agrifood systems. Climate change exacerbates these inequalities, because women's roles in agriculture are undervalued and their contributions are frequently overlooked. Furthermore, traditional gender norms and power dynamics limit women's decision-making power, making it difficult for them to adapt to climate-related challenges <sup>[7]</sup>. Addressing gender disparities and empowering women in agri-food systems are critical for long-term development and climate resilience. Globally,

36%

of women working in agriculture say they have less access to financing than men.

Women in the agriculture sector face significant gender disparities in accessing finance. They often have limited land ownership, weaker collateral assets, and lower levels of financial literacy compared to men. These barriers result in restricted access to credit, savings, insurance, and other financial services.

Access to finance is crucial for women in agriculture as it enables them to invest in modern farming techniques, quality inputs, purchase access markets, and expand their businesses. Financial resources can help women productivity constraints, overcome increase agricultural production, and enhance their income-generating opportunities.

Technology needs for climate adaptation in agriculture: Evidence from Africa

To tackle these challenges, technological innovation in the agriculture sector is essential for adapting to climate change. By adopting innovative approaches, farmers can enhance productivity, develop climate-resilient crops and livestock varieties, optimize water management, promote sustainable farming practices, and utilize digital tools for decision-making. These innovations not only reduce the negative impacts of agriculture on the environment but also empower farmers to adapt to climate challenges, minimize risks, and ensure food security and sustainability in the face of a changing climate. For instance, lack of access to information and communication technologies (ICTs) reduces the capacity of women to connect with markets, access financial services, and engage in e-commerce platforms [8]. While many innovations already exist, the challenge is their

accessibility by smallholder farmers and this need requires systematic attention.

This knowledge brief, explores important innovations and technologies necessary for adapting to climate change in Africa's agriculture sector. The following sections will discuss the significance of technological advancements, improved weather monitoring, climate-resilient crop varieties and livestock breeds, water management and irrigation technologies, sustainable soil management and conservation practices, and the adoption of digital farming solutions and ICT tools by farmers. By embracing these innovations, African farmers can enhance their resilience and contribute to a more sustainable and climate-resilient agricultural sector.

#### **1.1 WHY TECHNOLOGICAL INNOVATION IS KEY TO CLIMATE CHANGE ADAPTATION IN AFRICA?**



Africa, with its vast agricultural potential, is increasingly embracing digital farming solutions and ICT tools to improve agricultural productivity, sustainability, and profitability. These technologies harness the power of mobile applications, data analytics, and remote sensing to address key challenges that farmers face, such as weather uncertainty, limited access to market information, and a lack of precision in agricultural practices. However, successfully implementing and scaling up these solutions in rural areas presents its own set of challenges.<sup>[9]</sup>

According to ACBF's situational analysis <sup>[10]</sup>, the digital revolution during the pandemic created both opportunities and challenges for organizations' service delivery capacities. Agricultural digital services such as advisory solutions, e-commerce, and smart farming have expanded in developing countries. These digital solutions increased smallholder farmers' climate resilience and adaptive capacity, thereby increasing their income. However, obstacl es such as data costs, digital illiteracy, and gender-based digital divides must be overcome. Key challenges identified include a lack of individual capacity to interface with digital platforms, limited network coverage, and device availability. Overall, the digital revolution has the potential to improve agricultural service delivery, but more work is needed to address existing barriers and ensure inclusivity. By harnessing the power of innovation, Africa can address climate challenges, build resilience, and ensure a sustainable and prosperous future for its people.

#### **1.2 TECHNOLOGY NEEDS/GAPS FOR CLIMATE ADAPTATION IN AFRICAN AGRICULTURE**

As African agriculture faces the challenges of climate change, there is a growing recognition of the need to strengthen technology capacity and bridge existing gaps to facilitate effective climate adaptation. While progress has been made in adopting various climate-smart practices and technologies, there are still significant technology needs that must be addressed to enhance the resilience and adaptive capacity of African agriculture. These needs primarily revolve around:



Access to reliable climate data and early warning systems



Affordable and appropriate technological solutions



Capacity building for farmers and extension services



Development of contextspecific innovations

Addressing these technology gaps crucial to:



**Empower farmers** 



Promote sustainable agricultural practices



Ensure food security in the face of a changing climate



#### **1.2.1 Improved Weather Monitoring and Forecasting Systems**

#### **Weather Monitoring and Early Warning Systems**

Reliable weather monitoring systems, including weather stations, remote sensing, and satellite imagery, are essential for collecting accurate and timely weather data. Early warning systems can provide farmers with advanced information on weather patterns, helping them make informed decisions and take proactive measures to mitigate risks. Some innovations have been implemented on the continent to support local farmers to access reliable weather information as well as forecasting for improved farming.

Many regions in Africa lack a robust network of weather monitoring instruments, including weather stations, radars, and satellite receiving stations. This limited infrastructure leads to inadequate data coverage, making it challenging to gather accurate and timely observations for weather forecasting and analysis. Adequate training, education, and expertise in meteorology and related fields are crucial for operating and maintaining weather monitoring and forecasting systems. In Africa, there may be a shortage of trained meteorologists, data analysts, and technicians who can effectively utilize and interpret the available weather data and models. This shortage of human resources can limit the efficiency and accuracy of weather forecasts.



Mobile applications have revolutionized the way farmers access critical information. Weather alerts delivered through these apps enable farmers to make informed decisions regarding planting, irrigation, and pest management. Real-time weather updates help farmers mitigate risks associated with climate change and improve crop yields.

#### **Table 1: Weather Advisory Services in Africa**

| Name of Service   | Country              | Description   |
|---|----------------------|---|
| MaliCrop  | Mali                 | The app utilizes a decade's worth of data to greatly enhance the preci-<br>sion of forecasts. These forecasts, delivered in French and various local<br>languages, have gained significant traction since the project's inception<br>in July 2021, consistently reaching an audience of over 110,000 individ-<br>uals. <sup>1</sup> By providing invaluable insights, particularly to the farming com-<br>munity, including a significant number of women, this project empowers<br>them to make well-informed decisions on crop management.  |
| Kenya Rural Transfor-<br>mation Centers Digital<br>Platform | Kenya                | This platform empowers farmers by placing them at the center of a uni-<br>fied electronic ecosystem. <sup>2</sup> It enhances the connections between up-<br>stream, midstream, and downstream activities in the agriculture value<br>chain. This innovative model prioritizes youth and women, encouraging<br>their involvement in entrepreneurial activities and promoting value cre-<br>ation and decision-making. <sup>3</sup> Through access to agribusiness services<br>and information, such as broadcasting agricultural-cycle information<br>(weather forecasts, wholesale and retail commodity prices, higher yield<br>crops, etc.), as well as training on new farming practices (climate-re-<br>silient practices and/or green growth, pesticide and disease control,<br>extension services, and intervention strategies), this platform equips<br>farmers for success. |
| Agriculture and Climate<br>Risk Enterprise<br>(ACRE)        | Multiple             | The for-profit company ACRE Africa evolved from the Kilimo Salama project, established in 2009. <sup>4</sup> It is a Weather Index Insurance (WII) service that uses weather data and remote sensing to provide affordable crop insurance to smallholder farmers, protecting them from climate risks. In Kenya, the demand for WII was stronger for female-headed households as women tend to make less risky investment choices and are more vulnerable to weather-related risks. <sup>5</sup>   |
| SHAMBA HUB  | Tanzania             | SHAMBA HUB provides a variety of platforms that deliver valuable digi-<br>tized information to youth and smallholder farmers in Tanzania, empow-<br>ering them to enhance productivity and profitability. These platforms<br>include digital media channels like radio and TV programs, a Bulk SMS<br>messaging system, Youth Agribusiness Summits/Forums, a Farm Re-<br>cord Keeping Tool, and an Online Farm Extension Service. <sup>6</sup>  |
| Ignitia   | Ghana and<br>Nigeria | Ignitia is a Swedish Climate Intelligence Solutions based on 30 per-<br>son-years of research and development to address the specific chal-<br>lenges of forecasting rainfall and climate variability in tropical climates<br>such as West Africa and Brazil <sup>7</sup> . It provides location-specific information<br>on key weather parameters, such as rain, temperature, humidity, and<br>wind, through SMS and contains a forecast for the upcoming seven-day<br>period with low data usage.   |

<sup>1.</sup> https://www.unep.org/news-and-stories/story/app-helping-farmers-weather-climate-crisis-west-africa

4. https://acreafrica.com/about-us/

<sup>2.</sup> https://www.cuk.ac.ke/university-officially-launches-the-kenya-rural-transformation-digital-centers-platform-krtdcp-project-in-naku-ru-county-may-2023/#:~:text=The%20Co%2Doperative%20University%20has,in%20the%20agricultural%20value%20chain.

<sup>3.</sup> https://www.afdb.org/sites/all/libraries/pdf.js/web/viewer.html?file=https%3A%2F%2Fwuw.afdb.org%2Fsites%2Fdefault%2F-

files%2Fdocuments%2Fprojects-and-operations%2Fkenya\_-\_rural\_transformation\_centers\_digital\_platform\_-\_technical\_assistance\_ request.pdf#page=1&zoom=auto,-13,848

<sup>5.</sup> https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-018-0200-6

<sup>6.</sup> https://vc4a.com/ventures/shamba-hub/

<sup>7.</sup> https://ignitia.se/en/climate-intelligence/

| DigiFarm   | Kenya           | DigiFarm is a user-friendly integrated digital platform offered by Safar-<br>icom. It serves as a one-stop solution for farmers, providing a range of<br>services such as advisory services, market linkages, credit facilities, and<br>extension support. <sup>8</sup> With DigiFarm, farmers enjoy convenient access to<br>high-quality farm inputs at discounted prices, as well as input loans.<br>Additionally, they can access valuable learning content on farming tech-<br>niques and gain access to markets. DigiFarm goes beyond these fea-<br>tures by offering other value-added services like insurance yield cover<br>and extension services provided by remote agronomists at the DigiFarm<br>call center or on-ground DigiFarm Village Advisors (DVA). <sup>9</sup> |
|--|-----------------|---|
| Climate Information<br>and Early Warning Sys-<br>tem Project | Zambia          | The UNDP-supported Climate Information and Early Warning Systems<br>Project collaborated with the Zambian government's Meteorological<br>Department to enhance the livelihoods of rural Zambian farming fam-<br>ilies <sup>10</sup> . This was achieved by providing agro-meteorological services to<br>farmers' cooperatives, including women's clubs. <sup>11</sup> To ensure accessibility<br>and convenience, the project utilized mobile phones and solar-powered<br>radios. This enabled lead-farmers to receive weather forecasts even<br>while on the move.   |
| Tanzania Meteorolog-<br>ical Authority (TMA)<br>and FAO      | Tanzania        | This collaboration between FAO and TMA aims to enhance national agrometeorological weather bulletins and information dissemination to extension officers and farmers. The goal is to improve decision-making in agricultural production. As part of this initiative, FAO is focused on encouraging greater youth participation in farming by generating and disseminating weather information through various digital platforms such as social media, SMS messaging, and web-based platforms. <sup>12</sup>   |
| Rain for Africa (R4A)  | South<br>Africa | The R4A project seeks to enhance agricultural advisory services for farmers by leveraging accurate and location-specific weather and climate data. By utilizing the latest weather information from SAWS and incorporating ARC algorithms, the project assists farmers in making informed decisions regarding optimal planting, spraying, irrigation, and harvesting schedules. These advisories are accessible to farmers through the HydroNET web portal, AgriCloud Smartphone App, and USSD service, ensuring easy and widespread availability. <sup>13</sup>  |
| CommonSence  | Ethiopia        | CommonSense is dedicated to supporting smallholder farmers across various production areas in the country, focusing on different crops like sesame and malt barley. By delivering accurate weather forecasts, CommonSense equips farmers with crucial information to make informed decisions about their farming activities. Additionally, CommonSense also caters to agricultural unions, cooperatives, agro-processors, out-growers, microfinance institutions, and the Ethiopian Government, ensuring that the benefits of their services reach a wide range of stakeholders. <sup>14</sup>  |

- 11. https://wrd.unwomen.org/explore/insights/weather-forecasts-are-helping-zambian-women-farmers
- 12. https://www.climatelinks.org/blog/digital-access-weather-information-helps-young-tanzanian-farmers-build-resilience
- 13. https://www.rain4africa.org/

Technology needs for climate adaptation in agriculture: Evidence from Africa

<sup>8.</sup> https://cgspace.cgiar.org/bitstream/handle/10568/117449/GCA\_Final\_Dec2021.pdf?sequence=1&isAllowed=y

<sup>9.</sup> https://www.safaricom.co.ke/media-center-landing/frequently-asked-questions/digifarm

<sup>10.</sup> https://www.adaptation-undp.org/sites/default/files/downloads/zambia\_ciews\_brochure\_3.pdf

<sup>14.</sup> https://g4aw.spaceoffice.nl/en/g4aw-projects/g4aw-projects/7/commonsense.html

| Geo Gecko | Uganda   | It is a remote agricultural monitoring system that provides satellite-gen-<br>erated monthly statistics about the crops (crop health, soil moisture,<br>ground temperature and rainfall) as a no-cost service. <sup>15</sup> Geo Gecko then<br>uses farmer location and crop data to generate machine learning to gen-<br>erate crop quantification and crop forecasting models.   |
|-----------|----------|--|
| Esoko     | Multiple | Esoko is a digital agricultural services platform that provides a range<br>of services, including data collection and profiling services, weather<br>forecasts, agronomic advice, market linkages and insurance coverage<br>over a range of channels, including SMS, voice SMS and call centre. <sup>16</sup><br>A gender mainstreaming study in West Africa (Ghana) discovered that<br>women are 9% less likely to utilise the information on the Esoko platform<br>compared to men. <sup>17</sup> This is because men are often the natural targets<br>of most development interventions since they serve as opinion leaders<br>of the communities and families, tending to put males at an advantage<br>when it comes to information dissemination and technology adoption. |

Women's ability to benefit from digital climate tools may be hampered by gender disparities in access to technology and internet connectivity. Women in many African countries have limited access to smartphones, computers, and reliable internet services. Gender disparities in technological literacy and digital skills can have an impact on the adoption of digital climate tools. Furthermore, due to limited exposure to technology, educational disparities, and cultural norms that limit their engagement with digital platforms, women may face barriers in understanding and navigating these tools.<sup>[11].</sup>

#### **1.2.2 Climate-Resilient Crop Varieties and Livestock Breeds**

Developing and promoting climate-resilient crop varieties that can withstand extreme weather conditions, pests, and diseases is critical for adapting agriculture to climate change. This includes breeding crops with drought tolerance, heat resistance, flood tolerance, and pest and disease resistance to ensure agricultural productivity and food security.

Climate-resilient crop varieties require a variety of breeding techniques, including both traditional and modern approaches. To introduce desirable traits into crops, plant breeders use techniques such as hybridization, genetic modification, and marker-assisted selection. Drought tolerance, which allows crops to thrive in water-stressed conditions; heat resistance, which allows crops to withstand high temperatures; and flood tolerance, which allows crops to withstand excessive rainfall or waterlogging, are examples of these traits. Furthermore, breeding for pest and disease resistance protects crops from the increased risk of pests and diseases caused by climate change.

Climate-resilient livestock breed development and promotion are critical for ensuring the sustainability and productivity of livestock farming systems. Heat tolerance, disease resistance, efficient feed conversion, and adaptability to changing environmental conditions are all characteristics of climate-resilient livestock breeds. These characteristics allow livestock to thrive in areas with limited water resources, high temperature fluctuations, and high disease pressure. Farmers can reduce livestock mortality, increase productivity, and strengthen the resilience of their livestock-based livelihoods by breeding and promoting such livestock breeds.

<sup>15.</sup> https://vc4a.com/ventures/geo-gecko/

<sup>16.</sup> https://www.intellecap.com/wp-content/uploads/2022/04/Intellecap\_Report\_V.9\_31mar2022.pdf

#### **1.2.3 Water Management and Irrigation Technologies**



Precision agriculture technologies, such as Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing, enable farmers to optimize resource management, including water, fertilizers, and pesticides. These technologies help farmers make informed decisions by providing real-time information on soil moisture levels, nutrient content, and crop health, leading to improved resource efficiency, and reduced environmental impacts. Water management and irrigation technologies play a crucial role in enhancing the resilience and adaptive capacity of women in African agriculture, leading to their economic empowerment. Given that women contribute most of the labor in this sector, these technologies offer significant

benefits. For example, traditional manual irrigation methods, which are predominantly carried out by women, demand substantial physical exertion and time commitment.

Data analytics and remote sensing technologies play a crucial role in promoting precision agriculture in Africa. Using satellite imagery, drones, and ground sensors, these tools gather data on soil moisture levels, crop health, and pest infestations. By analyzing this data, farmers can make data-driven decisions, optimize resource allocation, and reduce input costs.

## **1.2.4 Sustainable Soil Management and Conservation Practices**

Africa's agriculture sector is increasingly recognizing the value of long-term productivity and environmental stewardship through sustainable soil management and conservation practices. Conservation agriculture techniques are being used to protect soil health and increase its resilience to the effects of climate change. Minima tillage, cover cropping, and crop rotation are all used to reduce soil erosion, improve water retention, foster biodiversity and ecological resilience and boost soil fertility.



Conservation agriculture protects soil structure, promotes microbial activity, and promotes nutrient cycling by minimizing soil disturbance and maintaining permanent soil cover. These practices not only increase crop yields but also mitigate the negative environmental effects of traditional farming methods.<sup>[3], [13]</sup>.

Nutrient management strategies, in addition to conservation agriculture, are critical for climate-smart farming in Africa. Farmers can reduce nutrient losses, improve nutrient uptake efficiency, and reduce the risk of soil degradation by optimizing fertilizer use. Precision application techniques, soil testing, and balanced fertilizer formulations tailored to specific crop requirements are all part of this. Integrated nutrient management strategies, such as the use of organic matter, biofertilizers, and crop residues, are also gaining popularity as viable alternatives to synthetic fertilizers. These strategies improve soil health, reduce greenhouse gas emissions, and increase agricultural system resilience to climate variability by promoting balanced nutrient cycling and reducing nutrient runoff.

Technology needs for climate adaptation in agriculture: Evidence from Africa

Furthermore, soil moisture monitoring and precision farming technologies are critical to African soil management. Water scarcity and unpredictable rainfall patterns are major challenges to agricultural productivity. Precision farming technologies, such as variable rate application systems and GPS-guided machinery, allow for site-specific management of inputs like water, fertilizer, and pesticides. This targeted approach ensures optimal resource allocation, lowers environmental risks, and increases farm efficiency.

Gender norms, roles, and power dynamics influence women's engagement in soil management and conservation practices. Gender norms and power relations affect women's access to land, credit, and extension services for soil conservation <sup>[14]</sup>.

Addressing gender disparities and empowering women through targeted interventions and policies that challenge existing gender norms and provide equal opportunities for women's active participation in soil management is imperative in the agriculture sector. In addition, it is important to encourage open discussions on gender equality, involving men and local communities, redistributing household responsibilities, and fostering equitable decisionmaking processes create supportive social environments for sustainable soil management and conservation practices.



Climate-resilient crop varieties and livestock breeds are essential for adapting agriculture to climate change. Breeding techniques such as hybridization and genetic modification help develop crops with drought tolerance, heat resistance, flood tolerance, and pest and disease resistance.



Climate-resilient livestock breeds possess characteristics like heat tolerance, disease resistance, and adaptability to changing environmental conditions, ensuring sustainability and productivity in livestock farming systems.

Water management and irrigation technologies like drip irrigation and precision agriculture reduce water use, improve resource efficiency, and increase crop yields. Precision agriculture utilizes GIS, GPS, and remote sensing to optimize resource management and provide real-time information on soil moisture levels and crop health.

# 2. Enabling factors for technology adoption



#### 2.1 AFFORDABILITY AND COST-EFFECTIVENESS



Technology affordability and cost-effectiveness in relation to expected benefits are important factors in driving adoption. According to studies, fertilizer and seed adoption are related to wealth (aff0rdability)<sup>[15]</sup>. In addition, technologies that offer clear economic advantages typically have a favorable Return on Investment. When the benefits outweigh the costs, the decision to adopt becomes more compelling. The potential for a quicker payback period and long-term profitability increases the likelihood of technology adoption. One such example is precision agriculture technologies which allow farmers to optimize their operations, increase yields, reduce input costs, and minimize environmental impact. However, the adoption of these technologies also depends on factors such as infrastructure availability, access to financing, training and technical support, and the specific needs and context of farmers and farming systems <sup>[16]</sup>.

#### **2.2 POLICY AND GOVERNANCE FRAMEWORKS**



Overall, well-designed policy and governance frameworks are crucial to facilitate the adoption, implementation, and scaling up of agricultural technologies in Africa. These frameworks should promote supportive policies, establish effective institutional arrangements, and provide adequate funding mechanisms to drive technology-driven agricultural transformation, leading to improved food security, increased income for farmers, and enhanced environmental sustainability. Some of the key frameworks for Africa include:

| Framework  | Description  |
|--|--|
| African Union Framework on<br>Climate Change                           | The African Union (AU) Framework on Climate Change provides a comprehensive<br>approach to addressing climate change challenges across Africa. It focuses on<br>promoting climate resilience, low-carbon development, and sustainable agricul-<br>ture through policy coordination and collaboration among AU member states.   |
| Comprehensive Africa Ag-<br>riculture Development Pro-<br>gram (CAADP) | CAADP is a continental policy framework developed by the African Union, aimed<br>at promoting agricultural transformation and food security in Africa. It recognizes<br>climate change as a critical factor in agricultural development and includes mea-<br>sures to support climate-smart agriculture, resource management, and resilience<br>building in the agricultural sector.                               |
| African Adaptation Initiative<br>(AAI)                                 | The African Adaptation Initiative is a pan-African effort that seeks to address cli-<br>mate change impacts and enhance adaptation across the continent. It focuses on<br>promoting climate-resilient agriculture and natural resource management through<br>policy advocacy, capacity building, and resource mobilization at the regional and<br>national levels.   |
| Africa Agriculture Transfor-<br>mation Scorecard                       | The Africa Agriculture Transformation Scorecard is an African Union monitoring<br>and evaluation framework that assesses the progress of agricultural transforma-<br>tion and resilience-building efforts in Africa. It tracks key indicators related to cli-<br>mate change adaptation, agricultural productivity, and policy implementation to<br>promote evidence-based decision-making and policy adjustments. |
| African Ministerial Confer-<br>ence on the Environment<br>(AMCEN)      | AMCEN is a platform for African environment ministers to discuss and coordi-<br>nate environmental and climate change issues. It provides an avenue for policy<br>dialogue, knowledge sharing, and collaboration on climate change and agricul-<br>ture-related policies and initiatives at the continental level.   |

#### Table 2: Africa's governance and policy frameworks on agriculture and climate change

Other relevant frameworks include the African Climate Policy Centre (ACPC), AU Declaration on land issues and Challenges in Africa, and the African Union Framework for Scaling-up Climate Smart Agriculture in Africa.

There is significant gender-responsive governance and policy frameworks concerning agriculture and climate change adaptation. For example, the Gender and Climate Change Action Plan for the Agriculture Sector in Eastern and Southern Africa strives to improve women's access to resources, technology, and capacity-building opportunities. In countries like Kenya and Ethiopia, their Gender and Climate Change Action Plans acknowledge the varying impacts of climate change on women and men, aiming to ensure policies and programs that are responsive to gender considerations. Furthermore, programs such as the Climate-Smart Agriculture and Rural Enterprise Program in Rwanda and the Climate-Smart Agriculture and Rural Transformation Program in Malawi promote sustainable agricultural practices, resilience, and mitigation, while addressing gender disparities in resource access, knowledge, and decisionmaking.

Overall, while Africa-level governance and policy frameworks have set the stage for addressing climate change and agriculture, their effectiveness ultimately depends on the commitment and actions of governments, stakeholders, and the availability of necessary resources. Continued monitoring, evaluation, and adaptive management of these frameworks are essential to ensure their effectiveness and drive tangible progress towards climateresilient and sustainable agriculture in Africa.



#### **2.3 CAPACITY DEVELOPMENT**

Most farmers, especially in rural areas, may lack the necessary digital literacy skills to effectively use these tools. Training programs and capacitybuilding initiatives are required to bridge this knowledge gap and empower farmers to leverage digital farming solutions. In addition, the cost digital farming solutions, such as mobile phones and data plans, can be a barrier for many farmers, and particularly women in rural areas. Affordable and accessible technologies need to be developed to ensure inclusivity and equity in the adoption of digital farming solutions. Lastly, the digital farming solutions need to be context-specific and tailored to the unique needs of different regions, crops, and farming systems.

Rural women often have lower levels of education and limited access to training opportunities compared to their urban counterparts. This lack of formal education and training hampers their ability to acquire the knowledge and skills needed to understand and respond to climate change challenges effectively.

Overall, there is a need to prioritize genderresponsive capacity development in the agricultural sector to ensure that women are equipped with the knowledge, skills, and resources necessary to effectively adapt to climate change challenges and contribute to sustainable agricultural development in Africa.

#### **2.4 ACCESS TO INFRASTRUCTURE**



As Africa seeks to expand the reach of its e-extension services, there are several challenges it needs to overcome. The situational analysis conducted by ACBF notes these similar challenges<sup>[10]</sup>. Given the need to access mostly rural farmers in Africa, who are most affected by climate change, access to the respective farmers is often a challenge especially for rural women in the agriculture sector. Rural women typically face greater difficulties in accessing and controlling productive resources such as land, credit, improved seeds, and agricultural inputs. Limited access to these resources restricts their capacity to adopt climate-resilient practices and technologies. For example, access to smartphones, internet connectivity, and reliable electricity is still limited. This hampers the widespread adoption of mobile applications and other ICT tools.

#### **2.5 PUBLIC-PRIVATE PARTNERSHIPS AND INNOVATION HUBS**



In Africa, the promotion of innovation and entrepreneurship in agricultural technology has been successful through various publicprivate partnerships and innovation hubs. One notable example is the International Centre for Tropical Agriculture (CIAT), a CGIAR research centre that focuses on developing and transferring agricultural technologies to developing countries. With several innovation hubs located in Africa, CIAT is dedicated to developing and promoting climate-smart agricultural technologies. Bv working closely with the private sector, NGOs, governments, development partners, and farmers, CIAT ensures that their research processes are inclusive and support more informed investments in agricultural systems. Their efforts prioritize limited resources towards a healthier, wealthier continent where access to healthy, affordable food is accessible to everyone.

The African Agricultural Technology Foundation (AATF) is also a thriving public-private partnership (PPP) established by the Rockefeller Foundation, the Government of Kenya, and the Bill & Melinda Gates Foundation. AATF is on a mission to develop and implement cuttingedge agricultural technologies that can support smallholder farmers in Sub-Saharan Africa to overcome productivity challenges and uplift their livelihoods. With a focus on improving farm productivity and enhancing the lives of farmers, AATF is committed to making a positive and lasting impact on the region's agricultural sector. Currently, it is active in 23 countries across East, Southern and West Africa.

The Alliance for a Green Revolution in Africa (AGRA) is an African-led and African-based institution that has been making a significant impact on transforming smallholder agriculture since its establishment in 2006. This publicprivate partnership (PPP) is successfully turning the solitary struggle of smallholder farmers into a thriving business. With a focus on 11 target countries, AGRA is leading an inclusive agricultural transformation in Africa that is increasing incomes and improving food security for 30 million farming households. AGRA has been working with partners across Africa to deliver proven solutions to smallholder farmers and thousands of indigenous African agriculture enterprises. Through its efforts, AGRA has built the necessary systems and tools for Africa's agriculture. By providing high-quality seeds, improving soil health, increasing market access and credit, and strengthening farmer organizations and agriculture policies, AGRA is making agriculture a profitable business for smallholder farmers.

## **3. Case studies and success stories/innovations**



Several initiatives are underway on the continent to expand the use of technology to adapt to climate change. This section builds on the Situational Analysis Report by providing more information on two case studies profiled in the report. Overall, these projects underline the importance of leveraging technology, tailoring services, providing access to information, facilitating knowledge transfer, fostering collaboration, and ensuring scalability to effectively address the needs of farmers and enhance agricultural practices in the respective regions.



Case Study 1: 8028 Farmer Hotline service - Ethiopia

The 8028 Farmer Hotline service in Ethiopia has emerged as a valuable resource for agricultural support and advice for over 440,000 farming households. This innovative service employs various communication channels, including video, interactive voice response (IVR), radio, and mobile phones, to provide agronomic advice to farmers. By leveraging technology, the hotline offers a convenient and accessible platform for farmers to receive timely and relevant information to enhance their agricultural practices. The project does not provide gender disaggregated information on its reach but indicates how its services we crucial during the pandemic, providing both crop and livestock advisories.

Through the hotline, farmers can access expert guidance on a range of topics such as crop cultivation, pest management, soil fertility, irrigation techniques, and market information. The video and IVR functionalities allow farmers to interact with agronomists, enabling them to ask questions, receive personalized advice, and learn about best practices. The radio component of the service disseminates agricultural information to a wider audience, reaching even those with limited access to mobile phones or the internet. The 8028 Farmer Hotline service has proven to be a valuable tool for knowledge transfer and capacity building among Ethiopian farming communities. By providing agronomic sharing advice and relevant information, the hotline contributes to improving crop yields, mitigating risks, and enhancing the overall productivity and resilience of farming households. This technology-driven initiative demonstrates the potential of leveraging digital platforms to extend support services and empower farmers with the information they need to make informed decisions and improve their livelihoods.



### Case Study 2: The Esoko helpline

The Esoko helpline in Ghana is a digital platform model that has been instrumental in providing essential agricultural services to over 300,000 farmers. This innovative platform serves as a one-stop solution, offering a range of services including market price information, weather forecasts, agronomic advice, and access to critical agricultural resources.

Through the Esoko helpline, farmers can receive real-time market price information, enabling them to make informed decisions about when and where to sell their produce for optimal returns. This helps to reduce information asymmetry and improve market transparency, empowering farmers to negotiate fair prices for their crops.

The platform also provides farmers with access to reliable weather

forecasts, which are crucial for effective farm planning and decisionmaking. By staying informed about weather patterns, farmers can better manage their planting schedules, irrigation, and pest control measures, leading to improved productivity and risk mitigation.

Agronomic advice is another key feature of the Esoko helpline, providing farmers with expert guidance on various farming practices. From crop selection to soil fertility management and pest control, farmers can access personalized recommendations and best practices, enhancing their agricultural techniques and optimizing yields.

By leveraging digital technology, the Esoko enables farmers to overcome geographical barriers, bridging the gap between rural and urban areas.

## 4. Conclusion

Technological innovation is key to climate change adaptation in Africa as it enables Africa communities to become more resilient and adapt to the impacts of climate change through developing and deploying innovative solutions, such as climate-resilient infrastructure, advanced early warning systems, and adaptive agricultural practices, societies can better withstand and recover from climate-related events like droughts, floods, and heatwaves. Another approach is providing tools and approaches to assess vulnerabilities, analyze climate data, model future scenarios, and identify appropriate adaptation measures. These innovations enable policymakers, planners, and communities to make informed decisions and prioritize actions based on scientific evidence. The following policy recommendations can enhance technology adoption in African agriculture.



#### **Promoting Sustainable Development**

Innovations in renewable energy, energy efficiency, sustainable agriculture, water management, and waste reduction contribute to reducing greenhouse gas emissions and promoting low-carbon development pathways. Technological solutions can allow for the decoupling of economic growth from carbonintensive activities, leading to more sustainable and climate-resilient societies.



#### **Enabling Access to Information**

Technology plays a crucial role in providing access to climate information, early warnings, and risk assessments to vulnerable communities in Africa. Improved communication channels, mobile applications, and online platforms facilitate knowledge sharing and empower individuals to make informed decisions regarding their safety, livelihoods, and resource management. Access to information helps build resilience and adaptive capacity at the local level.



#### **Unlocking Economic Opportunities**

Technological innovation in climate change adaptation creates new economic opportunities. The development and deployment of climatefriendly technologies often lead to the emergence of new industries, job creation, and investments. By fostering gender-responsive innovation, Africa can stimulate economic growth while addressing climate challenges, contributing to poverty reduction and sustainable development.



#### **Scaling Up Adaptation Efforts**

Technological innovation accelerates the scaleup of climate change adaptation efforts. By developing scalable and cost-effective solutions, innovations can be deployed across Africa, benefiting larger populations. Technologies also play a crucial role in bridging gaps in capacity and resources, enabling developing countries to leapfrog to more sustainable and resilient pathways.





## Fostering Collaboration and Knowledge Sharing

Technological advancements foster collaboration among stakeholders, including researchers, policymakers, businesses, and communities. Platforms for knowledge sharing, data exchange, and collaborative problem-solving facilitate the co-creation and dissemination of innovative solutions. Collaboration enhances learning, promotes best practices, and avoids duplication of efforts in climate change adaptation.



**Promoting Gender-Responsive Innovation** Involving women in the co-design and development of agricultural technologies is crucial. By adopting gender-responsive innovation approaches, we can ensure that these technologies effectively address the unique needs, preferences, and constraints faced by women farmers. Engaging women in the process of technology development and fostering their participation in decision-making contribute to the relevance and effectiveness of climate-smart technologies, ultimately enhancing women's resilience and adaptive capacity in agriculture.

#### Improving access to financial services

Farmers frequently face barriers to accessing financial services such as credit, savings, and insurance. However, opportunities to address this disparity exist with technology-enabled financial services. Mobile banking, digital payment systems, and innovative microfinance approaches can help bridge the gap. Women's ability to invest in climate-smart technologies and adapt to changing agricultural conditions is strengthened by providing them with affordable and easily accessible financial services. These policies help to empower women in agriculture while also promoting their resilience in the face of climate change.

In summary, technological innovation is key to climate change adaptation in Africa as it enhances resilience, improves adaptation strategies, promotes sustainable development, unlocks economic opportunities, enables access to information, scales up adaptation efforts, and fosters collaboration and knowledge sharing. By harnessing the power of innovation, Africa can address climate challenges, build resilience, and ensure a sustainable and prosperous future for its people.

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