REIMAGINING AGRICULTURAL RESEARCH IN AFRICA:

DEMAND INNOVATION AND TRANSFORMATION.

Fatunbi, A. O.
Odeke, M.
Njukwe, E.
Munoko, K.
Mabuza, M.

FARA
Forum for Agricultural Research in Africa

Reimagining Agricultural Research in Africa: Demand, Innovation and Transformation

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Forum for Agricultural Research in Africa
No 7, Flowers Avenue, New Achimota Mile 7
PMB CT 173, Accra, Ghana
Tel: +233 302 772823 / 302779421
Email: info@faraafrica.org

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Foreword

It is my distinct pleasure to introduce "Reimagining Agricultural Research in Africa: Demand, Innovation and Transformation," a timely and thought-provoking contribution to the discourse on agricultural transformation and sustainable development across our continent.

Africa is at a critical point in its development. With a fast-growing young population, rich natural resources, diverse farming environments, and growing markets, the continent has great potential to become a global leader in agriculture. To achieve this, we need more than just higher production. We must also strengthen the scientific systems that create the knowledge, technologies, and innovations needed for strong and competitive food systems.

Agricultural research is the foundation of progress in farming. Countries that have modernized their agriculture have done so by investing in science, innovation, education, and technology. Africa should take the same approach. As the organization responsible for coordinating agricultural research in Africa, FARA believes that science should stay at the heart of our agricultural development plans.

This book comes at a crucial time. Africa has launched important frameworks like CAADP, Agenda 2063, STISA-2034, S3A, SIA, and the AFSH-AP. These efforts give us a solid base, but their success relies on strong national research systems, good universities, effective innovation, steady funding, and lasting partnerships between governments, research groups, businesses, farmers, and development partners.

What sets this book apart is that it does more than just describe the current state of agricultural research. It gives a thorough look at the institutions, skills, funding, innovation, new technologies, and policies that shape research in Africa. More importantly, it shares a bold vision for the future, with practical ideas such as Agricultural Research Sovereignty, the Agricultural Research Transformation Index, and the Africa Agricultural Research Transformation Framework. These concepts push us to go beyond small changes and build research systems that are led by Africans, globally competitive, use digital tools, and can drive lasting change in agriculture.

The author brings a unique mix of scientific knowledge, policy experience, and hands-on work in agricultural research for development. He has worked closely with national governments, regional groups, international research centers, universities, and development partners. This background helps him connect science, policy, and real-world action, making this book both thoughtful and useful.

At FARA, we have always supported stronger agricultural research and innovation systems in Africa. These are keys to food security, better livelihoods, climate resilience, healthy soils, and jobs for our growing youth population. We also believe that Africa's agricultural future should be led by African institutions, experts, partnerships, and investments. As this book shows, for Africa to truly lead in science and agriculture, it must also fund its own progress.

I recommend this book to policymakers, leaders of National Agricultural Research Systems, universities, researchers, students, development partners, private sector actors, and everyone committed to Africa's agricultural future. It offers a clear picture of our current situation and a strong plan for our shared path forward.

I hope this book will spark thoughtful discussion, encourage new investment in agricultural science, and help build a resilient, innovative, food-secure, and prosperous Africa.

Dr. Aggrey Agumya
Executive Director
Forum for Agricultural Research in Africa (FARA)
Accra, Ghana

Preface

"Wisdom is like a baobab tree; no individual can embrace it alone." African Proverb.

For thousands of years, agriculture has shaped Africa's civilizations, cultures, and economies. Today, it is still the main source of income for almost 60% of people on the continent, makes up about 20 to 25% of Africa's GDP, and provides jobs for most rural families. Despite this, Africa still faces a high level of food insecurity and spends tens of billions of dollars each year on food imports. This situation raises an important question: how can a continent with so much land, biodiversity, and human talent still rely on external sources for technology, innovation, and even food?

The solution is not just about growing more crops but about having strong scientific systems to support agriculture. Major changes in farming, such as the Green Revolution in Asia and the agricultural transformation in Brazil, resulted from sustained investment in research, education, innovation, and technology. Countries thrive when they create their own knowledge rather than relying solely on what others have made. As another African proverb says, *"Knowledge is a garden; if it is not cultivated, it cannot be harvested."*

This book is based on the belief that agricultural research is more than just an academic activity. It is the driving force behind food security, economic growth, climate resilience, environmental health, industrial progress, and national success. The book argues that Africa's future in agriculture depends on building strong, well-funded, and competitive research systems that can develop solutions suited to the continent's diverse environments and social needs.

In recent decades, Africa has made great progress by setting up National Agricultural Research Systems, improving universities, building regional scientific networks, and adopting continent-wide plans like CAADP, Agenda 2063, STISA-2034, the Science Agenda for Agriculture in Africa, the Soil Initiative for Africa, and the Africa Fertilizer and Soil Health Plan. However, challenges such as fragmented institutions, insufficient funding, outdated infrastructure, limited business development, and uneven implementation still hinder the full impact of science on agriculture.

This book gives a thorough overview of agricultural research in Africa, covering its history, institutions, funding, people, innovation systems, performance, digital changes, biotechnology, and future possibilities. In addition to reviewing the facts, it introduces new ideas, including Agricultural Research Sovereignty, the Agricultural Research Transformation Index, and the Africa Agricultural Research Transformation Framework, to encourage discussion and guide policy changes.

The analyses in this book are based on scientific studies, African policy documents, institutional knowledge, and many years of hands-on work in agricultural research and innovation across the continent. These insights are not meant to be final answers, but rather an invitation to reconsider how Africa invests in knowledge as the key to lasting development.

In the end, Africa's transformation will depend not just on its natural resources, but on the strength of its scientific institutions and the willingness of its leaders to support them. If this book encourages governments, universities, research groups, development partners, businesses, and future scientists to build up African-led, African-owned, and African-funded agricultural research, then it will have achieved its goal. The journey to food security, economic strength, and global scientific leadership in Africa starts with investing in agricultural research.

Acknowledgements

The preparation of Reimagining Agricultural Research in Africa: Demand, Innovation and Transformation has been a truly collaborative endeavor, drawing upon the collective knowledge, experience, and commitment of numerous institutions and individuals dedicated to advancing agricultural research, innovation, and sustainable food systems across Africa.

Sincere appreciation is extended to the Directors of Research and Innovation of Africa's Sub-Regional Research Organizations CORAF, ASARECA, and CCARDESA for their technical leadership, professional insights, and unwavering commitment throughout the development of this publication. Their collaboration exemplifies the spirit of regional partnership that continues to strengthen Africa's agricultural research and innovation landscape.

The African Forum for Agricultural Advisory Services (AFAAS) is gratefully acknowledged for its important contribution to this initiative. Together with the Forum for Agricultural Research in Africa (FARA), these institutions collaborated in the design, refinement, and validation of the data collection instruments that underpin this publication. Their technical diligence ensured that the survey effectively captured the realities, opportunities, challenges, and emerging priorities shaping agricultural research systems across the continent.

Special appreciation is extended to the Directors General of National Agricultural Research Institutes (NARIs), the Heads of National Agricultural Research Systems (NARS), and their dedicated scientific teams across Africa. Their willingness to share institutional experiences, strategic perspectives, and technical knowledge through surveys, consultations, and professional engagements provided the evidence base upon which much of the analysis presented in this volume is founded. Their commitment to strengthening agricultural research and innovation continues to inspire confidence in Africa's scientific future.

Recognition is also extended to the African Union Commission (AUC), AUDA-NEPAD, the Regional Economic Communities (RECs), universities, higher education institutions, CGIAR Centers, development partners, and the many public and private organizations whose policies, investments, partnerships, and knowledge products have contributed significantly to the evolution of Africa's agricultural innovation ecosystem. Their sustained collaboration has strengthened the continent's capacity to generate and apply science in support of agricultural transformation.

The commitment and professionalism of colleagues at the Forum for Agricultural Research in Africa (FARA) are sincerely acknowledged. Their dedication to scientific excellence, innovation, policy dialogue, institutional coordination, and continental partnership has been instrumental in advancing agricultural research and innovation across Africa. Their technical reviews, constructive suggestions, and unwavering support substantially strengthened the quality of this publication.

Finally, heartfelt appreciation is extended to the thousands of researchers, university scholars, educators, extension professionals, policymakers, private-sector innovators, development practitioners, farmers' organizations, youth and women champions, and development partners whose collective efforts continue to shape Africa's agricultural future. Their dedication demonstrates that sustainable agricultural transformation is best achieved through shared vision, scientific excellence, strategic partnerships, and collective action.

It is hoped that this volume will serve not only as a reflection on the current state of agricultural research in Africa but also as a catalyst for renewed commitment to building stronger, more resilient, African-led, African-owned, and African-funded agricultural research and innovation systems capable of driving inclusive economic growth, food and nutrition security, environmental sustainability, and prosperity for present and future generations.

Acronyms and Abbreviations

Acronym	Meaning
AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
AARTF	Africa Agricultural Research Transformation Framework
AAS	African Academy of Sciences
AfCFTA	African Continental Free Trade Area
AFSH-AP	Africa Fertilizer and Soil Health Action Plan
AGRA	Alliance for a Green Revolution in Africa
AI	Artificial Intelligence
AIS	Agricultural Innovation System(s)
AITG	Agricultural Innovation Transformation Gap
APPSA	Agricultural Productivity Program for Southern Africa
AR6	Sixth Assessment Report (IPCC)
ARCG	Agricultural Research Capacity Gap
ARIG	Agricultural Research Implementation Gap
ARIP	Agricultural Research Investment Paradox
ARPD	Agricultural Research Performance Dashboard
ARS	Agricultural Research System(s)
ARTI	Agricultural Research Transformation Index
ARUA	African Research Universities Alliance
ASARECA	Association for Strengthening Agricultural Research in Eastern andCentral Africa
ASDAC	Africa Soil Data Centre
ASTI	Agricultural Science and Technology Indicators
AU	African Union
AUC	African Union Commission
AUDA-NEPAD	African Union Development Agency–New Partnership for Africa's Development
AUSO	African Union Soil Observatory
AUTM	Association of University Technology Managers
CAADP	Comprehensive Africa Agriculture Development Program
CAB	Commonwealth Agricultural Bureaux (CAB International)
CCARDESA	Centre for Coordination of Agricultural Research and Devebpment for Southern Africa
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CORAF	West and Central African Council for Agricultural Research and Development
COVID-19	Coronavirus Disease 2019
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CSA	Climate-Smart Agriculture
DNA	Deoxyribonucleic Acid
DSGD	Development Strategy and Governance Division
EAAPP	East Africa Agricultural Productivity Program
EPTD	Environment and Production Technology Division
FAAP	Framework for African Agricultural Productivity
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FCDO	Foreign, Commonwealth and Development Office (United Kingdom)

GDP	Gross Domestic Product
GIS	Geographic Information System
GIZ	German Agency for International Cooperation
IAR4D	Integrated Agricultural Research for Development
IARIW	International Association for Research in Income and Wealth
IARS	International Agricultural Research System(s)
IBDAR	Integrated Bio-Digital Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
ISNAR	International Service for National Agricultural Research
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
M&E	Monitoring and Evaluation
NAP	National Adaptation Plan
NARO	National Agricultural Research Organization
NARS	National Agricultural Research Systems
NASRO	North Africa Sub-Regional Organization
NDC	Nationally Determined Contribution
NERICA	New Rice for Africa
OECD	Organization for Economic Co-operation and Development
PPP	Public–Private Partnership
R&D	Research and Development
REC	Regional Economic Community
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
S3A	Science Agenda for Agriculture in Africa
SDG	Sustainable Development Goal
SIA	Soil Initiative for Africa
SPAC	Science and Partnerships for African Agriculture Conference
STISA-2024	Science, Technology and Innovation Strategy for Africa 2024
STISA-2034	Science, Technology and Innovation Strategy for Africa 2034
TAAT	Technologies for African Agricultural Transformation
TSO	Technical Support Organization
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WAAPP	West Africa Agricultural Productivity Program
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization

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Executive Summary

Africa is at a pivotal point in its agricultural development. By 2050, the continent will be home to about 2.5 billion people, or one -quarter of the global population. Meeting the food needs of this growing population, while creating jobs, restoring ecosystems, adapting to climate change, and competing in glob markets, is a major development challenge. However, Africa holds nearly 60% of the worlds uncultivated arable land, exceptional agroecological diversity, and the youngest workforce worldwide. The key questi is not whether Africa can transform its agriculture, but whether it has the scientific systems to realize this potential.

This book contends that agricultural research is the most strategic investment for Africa 's agricultural transformation. Countries such as Brazil, China, India, Japan, the Republic of Korea, and the Netherlands modernized their agriculture through sustained investment in agricultural science, research institutions, innovation ecosystems, and human capital. Their experiences show that lasting transformation depends on strong national research systems that generate locally adapted solutions, rather than relying on imported technologies.

"No nation has ever achieved sustained agricultural transformation by importing knowledge. Prosperity is built by investing in the institutions that create it."

Evidence shows that agricultural research yields some of the highest returns among public investments, with average annual social rates of return often between 20 and 60 percent. Research has produced improved crop varieties, climate -smart technologies, better livestock genetics, soi l fertility innovations, digital agriculture, and policy reforms that have transformed food systems globally. Despite these high returns, agricultural research remains underfunded in Africa. Public investment is often below international recommendations, and reliance on donor funding has fragmented priorities and weakened long-term sustainability. This contradiction is described as the Agricultural Research Investment Paradox (ARIP).

The book shows that Africa's agricultural challenge is primarily institutional, not technological. In the past two decades, African leaders have adopted several continental policy frameworks, including CAADP, the Malabo and Kampala Declarations, Agenda 2063, STISA-2034, the Soil Initiative for Africa, and the Africa Fertilizer and Soil Health Action Plan. Together, these provide a roadmap for transformation. However, implementation often falls short because many countries lack the scientific capacity, institutional structures, financing, and innovation ecosystems needed to turn continental goals into national action. This challenge is termed the Agricultural Research Implementation Gap (ARIG).

A central thesis of this book is that National Agricultural Research Systems (NARS) are the engines that turn policy aspirations into development outcomes. NARS should evolve from technology generators into dynamic innovation platforms that connect universities, extension services, private enterprises, farmers' organizations, development partners, digital platforms, and policymakers. Agricultural innovation is now seen as a collaborative ecosystem where knowledge flows in multiple directions, and research success is measured by productivity, commercialization, climate resilience, food security, employment, and societa impact—not just publications or released technologies.

The book further argues that strengthening Africa's agricultural research systems requires investment in six key areas: human capital development, modern research infrastructure, sustainable financing,

infrastructure, promoting interdisciplinary research, and building stronger connections among research institutions, universities, governments, agribusinesses, and farmers.

An important contribution of this book is the development of an integrated conceptual framework for analyzing and transforming Africa's agricultural research system. The framework introduces six interconnected concepts:

- Agricultural Research Capacity Gap (ARCG) – the gap between existing and required scientific capacity.
- Agricultural Research Implementation Gap (ARIG) – the disconnect between policy ambitions and implementation capability.
- Agricultural Research Investment Paradox (ARIP) – the mismatch between the high returns to research and persistent underinvestment.
- Agricultural Research Transformation Index (ARTI) – a proposed framework for assessing the maturity and transformation readiness of research systems.
- Agricultural Research Performance Dashboard (ARPD) – a monitoring framework for evaluating research performance, innovation, and development impact.
- Africa Agricultural Research Transformation Framework (AARTF) – an integrated strategic framework for reimagining Africa's agricultural research system.

Together, these concepts provide a coherent architecture for diagnosing constraints, measuring progress, guiding investment, and supporting evidence-based decision-making.

The book also recognizes that future agricultural research must go beyond traditional crop improvement. New priorities such as climate adaptation, soil restoration, biodiversity conservation, nutrition-sensitive agriculture, digital transformation, artificial intelligence, precision agriculture, circular bioeconomy, mechanization, renewable energy, and resilient food systems require multidisciplinary approaches. These approaches should combine natural sciences, engineering, economics, data science, public policy, and entrepreneurship. As a result, agricultural research institutions must become hubs for knowledge and innovation, generating technological, institutional, and policy solutions at the same time.

The future of African agriculture will depend not on the number of policies or imported technologies, but on the continent's ability to build resilient, well-financed, and innovation-driven agricultural research systems. Investment in agricultural research should be seen as strategic national infrastructure, essential for food security, economic competitiveness, climate resilience, industrialization, and human development.

This book ultimately calls for a new continental agreement on agricultural research. Governments, Regional Economic Communities, the African Union, development partners, universities, private enterprises, philanthropic organizations, and farmers must work together to make agricultural research the foundation of Africa's transformation. The future will belong not to nations that consume knowledge alone, but to those that create it. Africa's path to food sovereignty, economic prosperity, and sustainable development depends on investing in science, empowering researchers, strengthening institutions, and turning knowledge into innovation for current and future generations.

"If Africa is to feed itself, compete globally, and secure its future, it must move beyond importing technologies to producing knowledge. Agricultural research is not the destination of transformation—it is the engine that powers it."

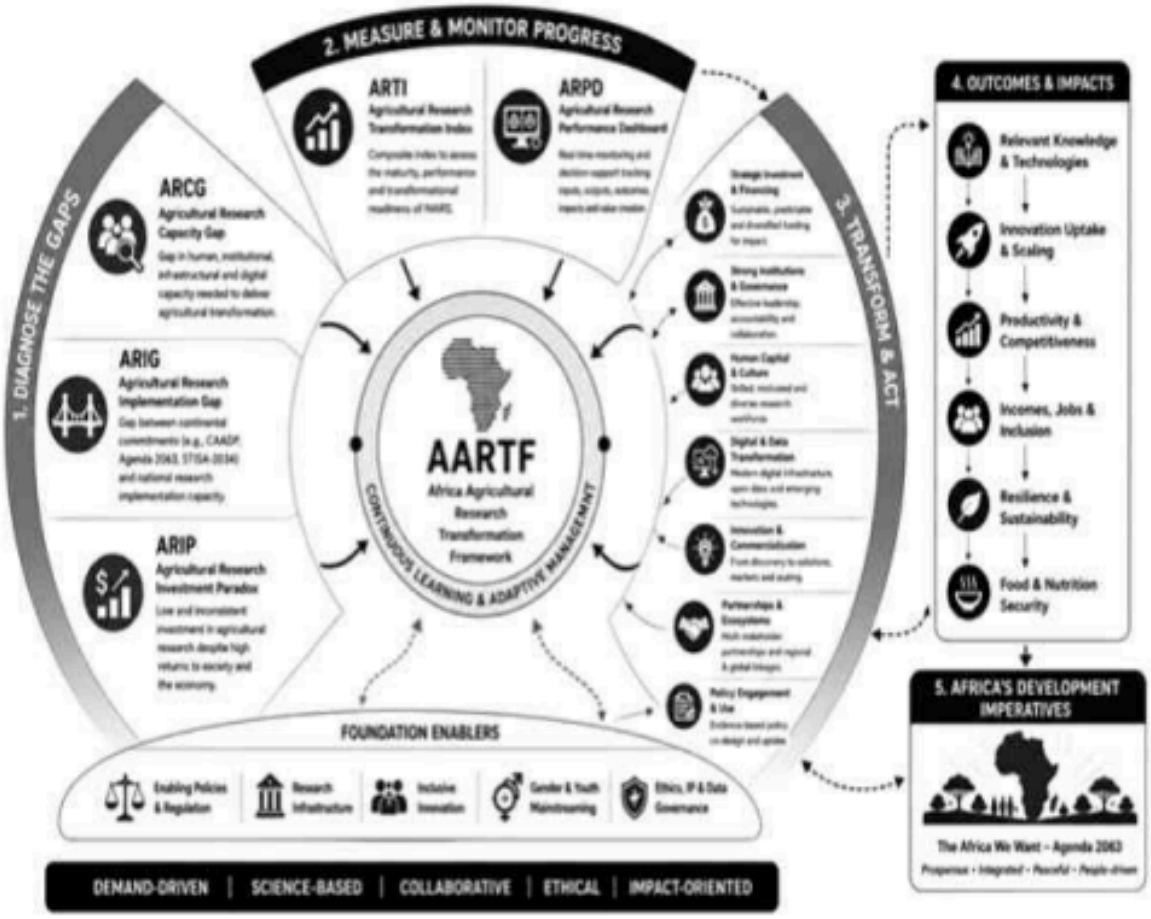

Figure ES.1. Mechanics for Reimagining Agricultural Research in Africa: Demand, Innovation and Transformation.

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CHAPTER 1

Introduction: The Current Status of Agricultural Research in Africa

Summary

This chapter has traced the historical evolution of agricultural research in Africa from its colonial origins through post-independence expansion, structural adjustment, and the emergence of contemporary agricultural innovation systems. It hasbeen shown that agricultural research consistently generates high economic and social returns, contributes significantly to productivity growth, and remains indispensable for food security and poverty reduction. Nevertheless, the effectiveness of research continues to be constrained by chronic underinvestment, unstable financing, weak innovation delivery systems, fragmented institutions, and inadequate policy coordination.

The analysis further demonstrates that Africa's persistent food import dependence is not primarily the consequence of inadequate scientific knowledge but of incomplete innovation systems that limit technology adoption, market integration, agro-industrial development, and resilience to external shocks. Consequently, the next phase of agricultural transformation requires a transition from research-led development to innovation-led transformation, supported by stable financing, regional collaboration, digital public goods, stronger university-industry partnerships, and outcome-oriented research evaluation.

Agricultural research, therefore, remains one of Africa's greatest strategic opportunities. If supported by coherent policies, sustained investment, and effective continental coordination, it can provide the scientific foundation for achieving food sovereignty, climate resilience, competitive agribusiness, and inclusive economic transformation throughout the twenty-first century.

1.1 Why Agricultural Research Matters

Agricultural research is one of the most strategic public investments for Africa's economic transformation because it drives agricultural productivity, strengthens food security, reduces poverty, enhances climate resilience, and stimulates broad-based economic growth. Unlike many public investments that yield short-term benefits, investments in agricultural research generate cumulative returns over decades through technological innovation, knowledge creation, institutional learning, and human capital development. Agricultural research should therefore be regarded not merely as a scientific enterprise but as strategic national infrastructure underpinning sustainable agricultural transformation.

Empirical evidence consistently demonstrates the high economic returns to agricultural research in Africa. Using data from 27 Sub-Saharan African countries, Alene and Coulibaly (2009) estimated an average social rate of return of about 55%, concluding that agricultural research significantly increased productivity while lifting approximately 2.3 million people out of poverty annually. However, they noted that these gains were moderated by rapid population growth, environmental degradation, and weak complementary services.

Long-term analyses further show that technological innovation has been the principal driver of agricultural productivity growth. Fuglie and Rada (2013) reported that following two decades of stagnation, agricultural productivity in Sub-Saharan Africa improved substantially after the mid-1980s, largely due to innovations generated through National Agricultural Research Systems (NARS) and international partnerships. Technologies developed through the CGIAR system had reached more than 34 million hectares by 2005, increasing production by an estimated 65% and generating returns of approximately US$6 for every US$1 invested in international agricultural research and about US$3 per dollar invested through national systems. The authors also emphasized that research investments require long gestation periods, with many benefits becoming fully evident only after two decades.

Improved methods for measuring productivity reinforce this evidence. Alene (2010) estimated that African agricultural productivity grew by approximately 1.8% annually between 1970 and 2004, considerably higher than earlier estimates. Agricultural research, policy reforms, trade liberalization, and improved climatic conditions all contributed to this growth, with research investments yielding an estimated annual social return of about 33%.

The importance of agricultural research is particularly evident in Africa, where wide yield gaps, declining soil fertility, climate variability, and dependence on rain-fed agriculture continue to constrain productivity. Since agriculture remains the primary source of livelihoods for much of the population, productivity gains generate economy-wide benefits through higher rural incomes, lower food prices, employment creation, and structural transformation. As noted by Diao et al. (2006), agricultural growth remains the most effective pathway for poverty reduction in most low-income African economies.

Nevertheless, research alone cannot transform agriculture. Its impact depends on complementary investments in extension services, farmer education, rural finance, input and output markets, secure land tenure, infrastructure, and enabling institutions. Farmers with better access to these services consistently adopt improved technologies more rapidly than resource-constrained households (Alene and Coulibaly, 2009). Agricultural research should therefore be viewed as the foundation of an integrated Agricultural Innovation System in which science, policy, extension, markets, and institutions work together to convert knowledge into productivity, livelihoods, and sustainable food security.

1.2 Historical Evolution of Agricultural Research in Africa

Agricultural research in Africa has changed alongside the continent's political, economic, and institutional shifts over the past century. Today's research institutions grew out of several key periods: colonial experimentation, post-independence nation-building, structural adjustment, and now a move toward regional and continental innovation.

Colonial governments first introduced formal agricultural research in Africa to boost export crops. They set up research stations, labs, and institutes focused on crops like cocoa, cotton, coffee, tea, rubber, and oil palm. The main goal was to serve the economic interests of the colonial powers, not local food security. While there was some investment in food crops such as rice in West Africa, most research focused on crops that could generate export income. This focus shaped the research priorities and structures that African countries inherited after independence.

After independence, African governments quickly grew their public agricultural research systems as part of national development plans. Agriculture was seen as key to food security, jobs, industrial growth, and foreign exchange earnings. Governments set up national research institutes, strengthened agricultural ministries, and invested heavily in education and research facilities. From 1961 to 1991, many more African countries hired over one hundred full-time agricultural researchers, showing both the shift from colonial institutions and a stronger commitment to science.

1.3 Evolution of National Agricultural Research Systems (NARS) in Africa

National Agricultural Research Systems (NARS) in Africa have shifted from being mainly government-run institutes to more diverse Agricultural Innovation Systems. At first, research was mostly done by national institutes under ministries of agriculture, with a focus on improving crops, adapting research, and creating new technologies. Over time, universities, CGIAR centers, extension services,

private companies, farmer groups, civil society, and regional research networks all became important parts of NARS. This change turned NARS into collaborative innovation systems instead of isolated research bodies (Roseboom et al., 1998; Spielman et al.; Sumberg and Parsey).

These institutional changes align with broader shifts in innovation policy. Ragasa et al. (2025) explain that the focus has shifted from just science, technology, and research results to an approach that values how different groups work together. More recently, the focus has shifted again to a transformative innovation model that highlights sustainability, scaling, inclusion, and big-picture change. These changes show that scientific discoveries alone are not enough to transform agriculture without strong innovation systems.

Even with these improvements, many African NARS still face operational challenges. Public investment in agricultural research in Sub-Saharan Africa nearly doubled from 1971 to 2016, yet research intensity fell to just 0.39% of agricultural GDP. More than 70% of countries spent less than the recommended 1% AgGDP . Most of the extra funding went to ongoing costs, especially salaries, leaving little for labs, fieldwork, equipment, or other activities. Still, universities played a major role in building Africa's scientific capacity, accounting for almost a third of agricultural researchers by 2016.

Funding for research remains highly unpredictable. Relying on short-term donor money has made research programs unstable. This has slowed breeding work, weakened long-term experiments, reduced facility maintenance, and led to the loss of skilled scientists (Stads and Beintema, 2015). Because agricultural research takes a long time, steady domestic funding is needed to keep making progress.

Different parts of Africa use different research models. In North Africa, research is mostly led by ministries and funded by their own governments. West and Central Africa depend more on regional coordination through CORAF. Eastern Africa has built more collaborative systems with universities, national institutes, CGIAR centers, and ASARECA. Southern Africa works together through CCARDESA and APPSA. These differences show that one model does not work for every country. Bigger economies can support their own national research systems, while smaller countries gain more from sharing regional centers of excellence.

Looking ahead, reforms should focus not just on increased investment but also on improving institutional performance. This means securing steady funding, strengthening partnerships between universities and research groups, improving regional collaboration, and measuring success by innovation, technology use, and real development impact, not just by staff numbers or budgets.

1.4 The Post-independence Agricultural Science Agenda in Africa

Since independence, Africa's agricultural science agenda has changed in response to shifting politics, economics, and ideas about how to transform agriculture. The main goal has always been modernization, but the methods have moved through three phases: state-led modernization, structural reform, and innovation systems for transformation.

In the first phase after independence, agriculture was at the heart of national development plans. Governments put significant resources into research institutes, experimental stations, extension services, and agricultural education. They saw agriculture as key to food security, jobs, industry, and growth. Most research was managed by public institutions, but priorities often remained focused on export crops, a holdover from colonial times, rather than on diverse food systems.

The second phase began during the economic crises and structural adjustment programs of the 1980s and 1990s. Budget cuts reduced public funding for agricultural research and extension, making countries more reliant on donor projects and weakening their institutions. Some policy changes improved markets and governance, but unstable funding still limited research (Alene and Coulibaly, 2009). Productivity gains after the early 2000s showed that scientific progress needs both investment and a supportive environment.

The third phase shifted the view of research from a simple process of creating new technology to an innovation-systems challenge in agricultural development. Major African initiatives such as CAADP, FAAP, and S3A emphasized that lasting change requires strong institutions, sound policies, partnerships, markets, and the sharing of technology, not just scientific breakthroughs.

As a result, agricultural research now covers more than just improving crops. It includes climate resilience, natural resource management, biotechnology, digital tools, mechanization, nutrition, value chains, entrepreneurship, and evidence-based policy. Innovation is now seen as a team effort among researchers, universities, extension workers, businesses, farmer groups, banks, and policymakers.

Even with these new ideas, many research systems still measure success by the number of technologies released rather than by real development outcomes. Future changes should focus on building stronger seed systems, digital tools, extension services, market connections, and partnerships between universities and industry. Agricultural research should be seen as the driving force behind strong, competitive, and inclusive food systems that support Africa's food security, climate resilience, and economic growth.

1.5 Major Achievements and Persistent Challenges of Agricultural Research in Africa

For more than sixty years, agricultural research has helped improve Africa's farm productivity, scientific skills, and innovation. While progress differs by country and crop, research has played a big role in advancing technology, boosting food production, reducing poverty, and building institutions. Still, ongoing problems with funding, the spread of new technology, collaboration, and the implementation of policies hold back its full impact.

A major achievement has been the rebound in farm productivity after years of little growth. Fuglie and Rada (2013) found that total factor productivity in Sub-Saharan Africa rose steadily after the mid-1980s, mainly due to new technology rather than increased land use. Alene (2010) also showed that productivity growth exceeded earlier estimates once technological progress was measured correctly. Even though productivity picked up after 2000, new technology has spread faster than improvements in how efficiently it is used, making technology adoption still a big challenge.

Agricultural research has led to many successful technologies thanks to teamwork among National Agricultural Research Systems, CGIAR centers, and regional groups. New types of maize, rust-resistant wheat, NERICA rice, drought-tolerant maize, cassava, sorghum, millet, and legumes have helped boost productivity, make farming more resilient to climate, and improve food security in many African countries. Regional programs like WAAPP, EAAPP, and APPSA have also built centers of excellence, encouraged the sharing of technology, increased scientific training, and accelerated the spread of new ideas across borders.

Africa's institutional landscape has also evolved considerably. Universities now play a central role in agricultural research through postgraduate training and innovation, while continental institutions

such as FARA and the Sub-Regional Organizations have strengthened coordination through initiatives including CAADP, the Framework for African Agricultural Productivity (FAAP), and the Science Agenda for Agriculture in Africa (S3A). These developments have shifted agricultural research from a technology-focused enterprise towards integrated Agricultural Innovation Systems.

Equally important are the weak adoption and scaling of research outputs. Evidence consistently shows that successful technology adoption depends on effective extension services, rural finance, secure land tenure, functioning input markets, farmer organizations, infrastructure, and market access. Consequently, scientifically sound technologies often fail to achieve widespread impact because supporting innovation systems remain weak.

Future agricultural research should therefore be evaluated not only by the technologies it generates but also by its capacity to deliver measurable development outcomes. Investment priorities must increasingly extend beyond research to include seed systems, extension, mechanization, digital advisory services, climate-risk management, and innovation delivery. The challenge for Africa is no longer simply to produce more technologies, but to ensure that scientific knowledge reaches farmers rapidly, equitably, and at scale.

1.6 Why Africa Still Imports Food Despite Decades of Agricultural Research

Africa's increasing food import bill is frequently interpreted as evidence of the failure of agricultural research. However, this perspective oversimplifies a more complex reality. While agricultural research has led to significant technological advancements, its impact has been surpassed by rapid population growth, evolving dietary preferences, weak market integration, limited agro-industrial development, and institutional barriers that restrict widespread adoption of new technologies. Consequently, food import dependence reflects systemic weaknesses across the entire food system rather than deficiencies in research alone.

Demographic pressure is a primary driver of increased food imports. From 1980 to 2007, Africa's food imports rose by approximately 3.4% annually, while the population grew by about 2.6% per year (FAO). Although agricultural production expanded during this period, productivity gains only marginally outpaced population growth. Additional constraints on domestic food production include declining arable land per capita, soil degradation, limited irrigation infrastructure, and heightened climate variability.

Rapid urbanization and increasing incomes have shifted consumer preferences toward wheat, rice, livestock products, edible oils, and processed foods. In these categories, demand has consistently outpaced local production. Projections suggest that imports of rice and wheat will continue to rise, and the African Development Bank estimates that the continent's annual food import bill approaches US$70 billion.

Agricultural research has yielded notable successes, such as improved maize and wheat varieties, NERICA rice, drought-tolerant maize, and enhanced cassava and legumes varieties. However, these advancements have largely remained localized and have not been sufficient to satisfy continent-wide demand. Furthermore, investments have predominantly targeted production, with less emphasis on post-harvest management, agro-processing, storage, logistics, and value-chain development. This imbalance has diminished the competitiveness of domestic food systems.

Limited regional market integration further exacerbates import dependence. Despite the continent's diverse agroecological zones, intra-African agricultural trade remains minimal due to inadequate transport infrastructure, non-tariff barriers, fragmented value chains, and inconsistent enforcement of regional trade agreements. Additionally, climate change, soil degradation, pest infestations, conflicts, and political instability continue to undermine productivity gains achieved through research.

In summary, Africa's reliance on food imports is indicative of an incomplete agricultural innovation ecosystem rather than a lack of scientific knowledge. Achieving sustainable food security necessitates complementary investments in seed systems, agricultural extension, mechanization, digital agriculture, irrigation, agro-industrialization, rural finance, regional trade, and evidence-based policy frameworks. The primary challenge is to develop innovation systems that can effectively translate scientific advances into transformative, continent-wide improvements in the food system.

1.7 Policy Perspectives and Pathways for Transforming Agricultural Research in Africa

Evidence indicates that agricultural research in Africa has led to significant improvements in productivity, poverty reduction, technological innovation, and institutional development (Alene and Coulibaly, 2009; Alene, 2010; Fuglie and Rada, 2013). However, the continent still experiences low productivity, increasing food imports, vulnerability to climate change, and slow structural transformation. This paradox highlights the limitations of agricultural innovation systems in effectively translating scientific advances into widespread development outcomes, rather than a failure of research itself.

Transforming the sector will require a fundamental reassessment of how agricultural research is financed, organized, and evaluated. Agricultural research should be regarded as strategic public infrastructure, similar to transport, energy, and digital systems, due to its broad benefits for food security, economic growth, environmental sustainability, and public health. Therefore, governments are encouraged to replace fragmented, project-based financing with predictable, long-term domestic investment, supplemented by mechanisms such as agricultural research endowment funds, blended finance, sovereign investments, and enhanced private-sector participation.

Strengthening regional collaboration is also essential. Organizations such as FARA, CORAF, ASARECA, CCARDESA, AARINENA, and continental initiatives under CAADP have demonstrated the benefits of shared research infrastructure, regional centers of excellence, postgraduate training, digital knowledge platforms, and continental databases. These regional public goods are especially critical for countries with limited scientific capacity.

Adopting multidisciplinary and innovative systems approaches in agricultural research is increasingly necessary. Addressing challenges such as climate change, soil degradation, nutrition, water scarcity, digital transformation, and evolving food systems requires collaboration among biological sciences, engineering, economics, environmental sciences, artificial intelligence, data science, and public policy. Concurrently, digital technologies including remote sensing, precision agriculture, artificial intelligence, and digital soil information systems present significant opportunities to enhance research efficiency, evidence-based decision-making, and technology dissemination.

Future performance assessments should prioritize evaluating technology adoption, productivity growth, climate resilience, employment creation, environmental sustainability, and economic impact, rather than focusing solely on publications and technologies released. Universities are expected to play a more prominent role in training multidisciplinary scientists with expertise in digital agriculture, entrepreneurship, and innovation management.

Ultimately, the transformation of Africa's agriculture will depend not only on increasing research activity but also on establishing resilient, well-financed innovation systems that can convert scientific knowledge into productivity, competitiveness, and inclusive economic development. Agricultural research should serve as the primary driver of Africa's transition toward a knowledge-based, food-secure, and globally competitive agricultural economy.

CHAPTER
2

The Political Economy of Agricultural Research in Africa

Chapter Summary
Agricultural research is widely recognized as one of the highest-return public investments, generating substantial benefits for agricultural productivity, food security, poverty reduction, and economic growth. Despite this evidence, agricultural research in Africa remains constrained by political, institutional, and financial factors that have limited its ability to drive agricultural transformation. This chapter argues that the challenges facing agricultural research are fundamentally political economy issues rather than purely scientific or technical concerns.
The chapter examines how the public-good nature of agricultural research, long investment horizons, and competing national priorities often result in chronic underinvestment in science and innovation. Although African governments have endorsed ambitious continental commitments through CAADP, the Malabo and Kampala Declarations, and Agenda 2063, actual investment in agricultural research remains below recommended levels, while many research institutions continue to depend heavily on donor financing. Such dependence has contributed to fragmented research agendas, weak institutional autonomy, and reduced national ownership of research priorities.
The chapter further explores the consequences of ageing scientific capadty, inadequate infrastructure, limited operational funding, and weak governance on the performance of National Agricultural Research Systems. It concludes by proposing a transformative agenda centred on increased domestic financing, stronger political commitment, institutional reforms, enhanced private-sector participation, regional collaboration, and strategic human capital development. Ultimately, the chapter positions agricultural research as a strategic national investment essential for achieving food security, climate resilience, economic competitiveness, and Africa's longterm development aspirations.

2.1 Introduction

Agricultural research is widely regarded as one of the most effective forms of public investment for enhancing agricultural productivity, improving food security, reducing poverty, and fostering economic transformation. Empirical evidence from both developed and developing countries demonstrates that investments in agricultural research yield exceptionally high social returns, frequently surpassing 20–40% annually and, in some instances, exceeding 60% (Alston et al., 2011; Fuglie and Rada, 2013). Nevertheless, agricultural research in Africa remains persistently underfunded, institutionally fragile, and constrained by political and economic factors that undermine its long-term effectiveness.

The challenges facing agricultural research extend beyond scientific or technical concerns and are fundamentally rooted in political economy. Decisions about public expenditure, institutional reforms, research priorities, and technology adoption are influenced by governance structures, political incentives, competing development priorities, and external financing mechanisms. As a result, the effectiveness of agricultural research systems depends equally on political commitment, institutional capacity, and scientific excellence.
This chapter analyzes the political economy of agricultural research in Africa through six interrelated themes: agricultural research as a public good, the politics of agricultural investment, donor dependency and external influence, competing national priorities, institutional fragility, and the

economics of science and innovation. The central argument is that strengthening Africa's agricultural research systems necessitates not only increased investment but also reforms to enhance governance, financing, institutional resilience, and sustained policy commitment.

2.2 Agricultural Research as a Public Good

Agricultural research possesses the defining characteristics of a public good. The knowledge produced is largely non-rivalrous and partially non-excludable, allowing its benefits to be widely shared without reducing their value. Innovations such as improved crop varieties, soil fertility management practices, pest-control technologies, and digital advisory services provide advantages that extend beyond individual farmers to communities, value chains, and national borders. Since private investors are unable to fully appropriate these widespread benefits, agricultural research is generally underprovided by markets, which underscores the need for sustained public investment.

Empirical evidence consistently supports this economic rationale. Alston et al. (2011), in their review of over 1,000 impact studies, found that agricultural research yields some of the highest returns among all forms of public expenditure. In Africa, where smallholder farmers predominate and market imperfections are pervasive, the public-good nature of agricultural research is particularly evident.

Paradoxically, these characteristics also contribute to persistent underinvestment. The benefits of research are often diffuse, accrue over extended periods, and are seldom apparent within the timeframe of political cycles. As a result, governments tend to prioritize investments that yield immediate and visible political returns, such as fertilizer subsidies, infrastructure projects, or emergency food programs, over long-term scientific research. Because many research programs require 10 to 20 years to realize their full benefits, agricultural research often receives lower budgetary priority despite its superior long-term economic. This misalignment between the timing of political incentives and research impacts is a principal factor contributing to underinvestment in African agricultural research. While governments frequently acknowledge the significance of science and innovation, public financing is often inadequate to support the long-term research programs necessary to address challenges such as climate change, food insecurity, soil degradation, and agricultural transformation. Addressing this gap requires viewing agricultural research not simply as a budgetary expense but as strategic public infrastructure vital for sustained national development.

2.3 The Politics of Agricultural Investment

Agricultural investment decisions are fundamentally shaped by political considerations. Public resources are seldom allocated based exclusively on economic efficiency; instead, allocations reflect the competing interests of political leaders, government agencies, development partners, producer organizations, and other stakeholders. As a result, agricultural research frequently loses out to expenditures that offer greater immediate political visibility and electoral advantages.

Despite agriculture remaining the largest source of employment in most African countries, its political influence has diminished as economies have become more urbanized and diversified. Consequently, governments often prioritize highly visible investments, including roads, fertilizer subsidies, food imports, irrigation projects, and social protection Programs, over long-term commitments to scientific research. Although these interventions yield immediate political gains, they seldom address the underlying structural factors affecting agricultural productivity.

Continental initiatives such as the Comprehensive Africa Agriculture Development Program (CAADP) and the Malabo and Kampala Declarations aimed to counteract this trend by urging governments to

allocate a minimum of 10% of public expenditure to agriculture. Nevertheless, implementation has been inconsistent. While overall agricultural spending rose between 2000 and 2016, investment in agricultural research increased at a slower rate, resulting in a decline in research intensity from approximately 0.54% of agricultural GDP in 2000 to about 0.39% in 2016.

The extended time frame required for agricultural research to yield measurable development impacts further diminishes political incentives for investment. Scientific Programs often necessitate 10 to 20 years before producing tangible results, while elected governments generally operate within much shorter political cycles. As a result, research budgets are often among the first to be reduced during periods of fiscal constraint.

Political factors can also shape research priorities. In certain countries, funding decisions tend to favor commodities, regions, or constituencies with political significance rather than aligning with broader national development priorities. This practice undermines scientific independence and reduces the efficiency of research investments. Enhancing evidence-based planning, transparent financing, and institutional autonomy is therefore critical to aligning agricultural research with long-term national development objectives.

2.4 Donor Dependency and External Influence

External development partners have been instrumental in supporting agricultural research in Africa, especially since the structural adjustment period of the 1980s and 1990s. Investments from CGIAR centres, the World Bank, FAO, IFAD, USAID, the European Union, the Bill and Melinda Gates Foundation, and various bilateral agencies have funded research infrastructure, postgraduate training, technology development, and institutional capacity. These contributions have facilitated notable progress in crop improvement, livestock research, natural resource management, and innovation systems.

However, significant reliance on donor financing has introduced structural vulnerabilities. According to ASTI data, around 2000, donor funding represented approximately 35% of agricultural research expenditure across Africa, and in several countries, it accounted for 50 to 75% of total research budgets. This level of dependence exposes research institutions to funding volatility, rendering long-term scientific Programs susceptible to shifts in donor priorities and project cycles.

A further challenge concerns the alignment of research agendas. Since funding opportunities frequently shape research priorities, institutions may adjust their Programs to align with external interests rather than nationally identified needs. This dependence on external agendas can undermine national ownership, diminish policy relevance, and restrict investment in strategic areas that require sustained long-term commitment.

Project-based funding typically prioritizes short-term outputs and measurable deliverables, frequently at the expense of institutional strengthening, fundamental research, and scientific continuity. When projects end, valuable expertise, infrastructure, and research momentum may be lost, thereby weakening institutional resilience.

The goal is not to diminish international collaboration but to achieve a more balanced approach. Donor resources should increasingly serve to complement, rather than replace, domestic investment. Enhanced national financing mechanisms, co-financing arrangements, agricultural research endowment funds, and increased private-sector participation will empower African

countries to pursue research agendas aligned with national priorities while sustaining effective international partnerships. Ultimately, sustainable financing is essential for strengthening scientific sovereignty and ensuring that agricultural research remains responsive to Africa's long-term development goals.

2.5 Competing National Priorities

African governments are under growing pressure to distribute limited public resources among competing sectors such as health, education, infrastructure, energy, security, social protection, and debt servicing. In this constrained fiscal context, agricultural research frequently receives lower priority, as its benefits are long-term and less immediately visible compared to investments in roads, hospitals, schools, or subsidy programs.

Recent shocks such as the COVID-19 pandemic, climate extremes, food price inflation, rising public debt, and geopolitical instability have intensified these pressures. As a result, many governments have redirected resources toward emergency response and social protection. Although these interventions are necessary, they often reduce investment in long-term research and innovation.
Agricultural research is further constrained by a collective-action problem. While farmers, consumers, agribusinesses, and society benefit from scientific innovation, these groups are often fragmented and have limited influence on public expenditure decisions. In contrast, recipients of subsidies and direct transfers tend to be more organized and politically influential. Consequently, research receives less attention despite its proven long-term contributions to productivity, food security, and economic growth.

2.6 Fragility of Agricultural Research Institutions

Despite notable progress in recent decades, many National Agricultural Research Systems (NARS) remain institutionally fragile. Ongoing challenges such as financial instability, aging infrastructure, shortages of skilled scientists, weak governance, and limited operational autonomy continue to constrain research performance across much of the continent.

A significant concern is the aging scientific workforce. ASTI studies indicate persistent shortages in key disciplines, including plant breeding, soil science, agricultural engineering, biotechnology, and veterinary sciences. Many senior researchers are nearing retirement, while recruitment and postgraduate training have not kept pace, resulting in a substantial capacity gap. Financial constraints exacerbate these challenges. In many institutions, salaries account for the majority of available budgets, leaving insufficient resources for laboratories, field experiments, equipment maintenance, digital systems, and technology dissemination. Institutional fragmentation further reduces efficiency, as multiple organizations frequently conduct overlapping research with limited coordination.

Political interference further undermines institutional effectiveness. Frequent leadership changes, politicized appointments, and inconsistent policy direction weaken scientific independence and hinder long-term planning. In countries affected by conflict, damaged infrastructure, displacement of researchers, and disruption of long-term experiments further erode scientific capacity. Building resilient research institutions requires stable financing, improved governance, increased institutional autonomy, and enhanced regional collaboration.

2.7 The Economics of Science and Innovation

Agricultural innovation is fundamentally an economic process that involves investments in

knowledge generation, technology development, diffusion, and adoption. Research generates value by increasing productivity, reducing production costs, strengthening climate resilience, improving nutrition, protecting natural resources, and expanding market opportunities. However, these benefits typically materialize only after 10 to 25 years, positioning agricultural research as a long-term public investment.

This long gestation period presents a persistent financing challenge. Private investors generally prefer short-term returns, while governments are subject to electoral pressures that prioritize immediate outcomes. Therefore, sustained public investment is essential to maintain long-term research programs. Participation in agricultural research remains limited across much of Africa and is concentrated mainly in commercially attractive commodities and a few countries, particularly South Africa. Expanding private investment will require stronger intellectual property protection, better-functioning markets, reduced investment risks, and effective public-private partnerships.

Contemporary innovation theory increasingly conceptualizes research as part of an **Agricultural Innovation System (AIS)** rather than as a linear technology generation process. Effective innovation relies on collaboration among universities, research institutes, extension services, private firms, farmer organizations, financial institutions, and policymakers. Equally important is **absorptive capacity, defined as** the ability of institutions and farmers to acquire, adapt, and apply new knowledge. Investments in higher education, postgraduate training, digital infrastructure, extension, and knowledge management are therefore essential complements to research funding.

These considerations underscore that the economics of agricultural research extends beyond financing scientific discovery. Achieving sustainable impact depends on developing innovation systems that can translate research investments into widespread technology adoption, productivity growth, and long-term economic transformation.

2.8 Pathways for Transforming Agricultural Research in Africa

The political economy challenges facing agricultural research in Africa are significant but can be overcome. Evidence from Brazil, China, India, and other emerging economies demonstrates that sustained investment in science, innovation, and robust institutions can drive improvements in agricultural productivity, food security, and economic development (World Bank, 2008; Alston et al., 2011; Fuglie, 2018). Achieving transformation in Africa necessitates reforms that address both technical and political barriers.

Table 2.3. Strategic Pathways for Transforming Agricultural Research in Africa

Strategic Pillar	Priority Actions	Expected Outcome
Financing	Sustainable domestic investment, endowment funds, blended finance	Stable research funding
Governance	Political accountability, autonomous institutions	Strong NARS
Human Capital	Postgraduate training, leadership, multidisciplinary skills	World-class scientists
Infrastructure	Modern laboratories, digital platforms	Improved research quality
Private Sector	PPPs, innovation funds, commercialization	Increased innovation uptake
Regional Integration	FARA, SROs, Centers of Excellence	Shared research capacity
Scientific Sovereignty	Reduced donor dependency, African ownership	Independent research agenda
Strategic Positioning	Recognize research as national infrastructure	Sustainable agricultural transformation

2.8.1 Sustainable Domestic Financing

A primary priority is to increase predictable domestic investment in agricultural research. Most African countries invest substantially below the African Union/NEPAD target of allocating **at least 1% of Agricultural GDP (AgGDP)** to agricultural research and development. Average agricultural R&D investment across the continent was approximately **0.4% of AgGDP**, reflecting persistent underinvestment in national agricultural research systems (Beintema & Stads, 2017; Stads et al., 2021). Governments are encouraged to establish stable financing mechanisms such as agricultural research endowment funds, commodity levies, sovereign innovation funds, blended finance, and dedicated budget allocations to reduce reliance on annual budget cycles and donor funding. Regional financing windows managed by continental institutions could further enhance financial stability.

2.8.2 Strengthening Political Accountability

Agricultural research should be integrated into national and continental accountability frameworks, including CAADP, the Malabo Declaration, and the Kampala Declaration. Performance assessments should encompass not only agricultural production but also research investment, scientific capacity, innovation systems, and technology dissemination. The development of a continental agricultural research scorecard, coordinated by the African Union and Regional Economic Communities, could enhance transparency and reinforce political commitment.

2.8.3 Expanding Private-sector Participation

Private investment in agricultural research remains limited throughout much of Africa, despite expanding opportunities in seed systems, biotechnology, digital agriculture, mechanization, and food processing. Governments can foster enabling environments by implementing tax incentives, innovation funds, matching grants, venture capital support, and public-private partnerships. Enhanced collaboration among research institutions, universities, agribusinesses, financial institutions, and farmer organizations is essential to accelerate commercialization and technology adoption.

2.8.4 Building Resilient Research Institutions

Modern agricultural research depends on institutions that are autonomous, well-governed, and sufficiently equipped. Reforms should focus on strengthening governance, competitive funding, laboratory infrastructure, digital platforms, knowledge management, and institutional autonomy. Additionally, promoting regional resource sharing through organizations such as FARA, CORAF, ASARECA, CCARDESA, and NASRO is critical.

2.8.5 Investing in Human Capital

Africa's future competitiveness relies on cultivating a new generation of multidisciplinary scientists. Increased investment in postgraduate education, mentorship, leadership development, and emerging fields such as biotechnology, artificial intelligence, digital agriculture, climate science, engineering, and innovation management is essential. Universities should enhance partnerships with research institutes and industry to ensure that training aligns with future scientific and market demands.

2.8.6 Promoting Regional Integration

Regional cooperation provides substantial economies of scale in areas such as biotechnology, climate research, gene banking, advanced laboratories, postgraduate

training, and digital knowledge systems. The African Continental Free Trade Area (AfCFTA) also presents opportunities to harmonize seed regulations, biosafety frameworks, research standards, and technology dissemination, thereby strengthening agricultural innovation across the continent.

2.8.7 Reducing Donor Dependency

International partnerships will continue to play a significant role; however, long-term sustainability depends on increased domestic ownership of research financing. Donor resources should be used to leverage national investment through co-financing, matching grants, and blended financing. Innovative instruments such as climate finance, green bonds, philanthropic funds, carbon markets, and agricultural innovation trusts can diversify funding sources and reinforce scientific sovereignty.

2.8.8 Recognizing Agricultural Research as a Strategic National Asset

A critical reform involves redefining the perception of agricultural research. It should be regarded not as discretionary expenditure, but as strategic national infrastructure that supports food security, climate resilience, industrialization, economic competitiveness, and sustainable development. Similar to roads, energy systems, and digital infrastructure, agricultural research generates long-term national wealth through knowledge creation and innovation. The central issue for Africa is not whether investment in agricultural research is affordable, but whether it can afford to forgo investment in the science and innovation systems that will shape its future prosperity.

2.9 Conclusion

Agricultural research remains one of Africa's most valuable yet underutilized development assets. Although it consistently generates high social and economic returns, its impact continues to be constrained by political economy factors including chronic underinvestment, donor dependence, institutional fragility, fragmented governance, and competing national priorities. These challenges demonstrate that strengthening agricultural research requires more than scientific excellence; it demands sustained political commitment, stable financing, institutional reform, and stronger innovation systems.

The future of African agriculture will ultimately depend on the continent's ability to generate, adapt, and apply scientific knowledge through resilient National Agricultural Research Systems supported by effective regional collaboration and long-term domestic investment. Countries that recognize agricultural research as a strategic national asset will be better positioned to achieve the aspirations of Agenda 2063, the CAADP Kampala Declaration, the Sustainable Development Goals, and a more competitive, food-secure, and climate-resilient agricultural economy.

Box 2. Emerging Challenge: Protecting Africa's Agricultural Data and Intellectual Assets in the AI Era

The rapid advancement of artificial intelligence (AI), digital agriculture, remote sensing, genomics, and big data analytics is transforming agricultural research worldwide. While these technologies present unprecedented opportunities for accelerating scientific discovery and improving decision making, they also introduce significant challenges relating to the ownership, governance, and equitable use of Africa's agricultural knowledge, datasets, and biological resources.

Over several decades, African governments, National Agricultural Research Systems (NARS), universities, CGIAR Centres, and development partners have generated extensive datasets on soils, climate, crops, livestock, biodiversity, and indigenous agricultural knowledge. These publicly funded resources now constitute valuable digital assets that increasingly serve as training data for global AI models, digital platforms, and commercial analytics. Without appropriate governance mechanisms, there is a growing risk that these strategic resources may be extracted, commercialized, or incorporated into proprietary technologies without adequate recognition, equitable benefit-sharing, or meaningful participation by African institutions.

As National Agricultural Research Systems embrace digital agriculture, remote sensing, artificial intelligence, and genomics, safeguarding African data sovereignty becomes a strategic imperative. Public–private partnerships and international scientific collaborations should be governed by robust legal, ethical, and institutional frameworks that prevent the unauthorized extraction or commercial exploitation of African agricultural data, intellectual property, indigenous knowledge, and genetic resources. Such frameworks should ensure fair attribution, transparent data governance, equitable benefit-sharing, and the free, prior, and informed consent of national institutions and local knowledge holders.

This challenge extends beyond conventional intellectual property protection. It encompasses broader issues of digital sovereignty, data governance, AI ethics, cybersecurity, digital sequence information (DSI), and responsible innovation. Future agricultural competitiveness will increasingly depend not only on Africa's capacity to generate scientific knowledge but also on its ability to retain strategic control over the data, algorithms, digital infrastructure, and biological resources that underpin next-generation agricultural innovation.

As Africa implements the CAADP Kampala Declaration and accelerates investment in digital agricultural innovation, strengthening legal and institutional frameworks for agricultural data governance should become a continental priority. Protecting Africa's digital and biological assets is essential to ensuring that the benefits of AI-enabled agricultural research contribute directly to African food systems, scientific leadership, and long-term economic transformation.

CHAPTER 3

Agricultural Research as the Knowledge Engine for Africa's Development Agenda

Chapter Summary

This chapter advances an original conceptual argument: **continental declarations establish direction, but agricultural research enables implementation** By introducing the **Agricultural Research Implementation Gap (ARIG)**, it reframes the discussion from whether Africa has adequate policies to whether it has sufficient scientific and institutional capacity to implement them. The chapter therefore positions **National Agricultural Research Systems (NARS)** as the principal mechanism through which continental commitments are domesticated into national strategies, technologies, innovations, and measurable development outcomes, providing a conceptual bridge to the next chapter on the institutional architecture of agricultural research in Africa

3.1 Introduction

Since the early twenty-first century, Africa has exhibited strong political commitment to agricultural transformation through a series of continental frameworks, such as the Comprehensive Africa Agriculture Development Program (CAADP), the Maputo, Malabo, and Kampala Declarations, Agenda 2063, the Science, Technology and Innovation Strategy for Africa (STISA-2034), the Soil Initiative for Africa (SIA), the Africa Fertilizer and Soil Health Action Plan (AFSH-AP(African Union, 2025; AUC, 2025; UN, 2015). Collectively, these initiatives establish agriculture as a central driver of economic growth, food security, climate resilience, industrialization, and sustainable development.

Despite this comprehensive policy architecture, the pace of agricultural transformation has been slower than anticipated. Agricultural productivity remains low, food imports are increasing, approximately 65% of Africa's productive land is degraded, and many countries remain susceptible to climate-related shocks (FAO and AUC, 2024; AGRA, 2024). These conditions indicate that ambitious continental commitments have not consistently resulted in effective national implementation.

One of the most significant constraints is the limited capacity of National Agricultural Research Systems (NARS) to translate continental aspirations into locally adapted technologies, evidence, and innovations. Agricultural transformation is fundamentally driven by knowledge. Evidence from Asia and Latin America demonstrates that sustained investments in research, higher education, innovation, and effective linkages among research institutions, policymakers, extension services, and farmers are essential for achieving lasting productivity growth and food-system transformation.

Agricultural research serves as the knowledge engine that enables the domestication of continental policies through technology development, scientific evidence, human capital, and decision-support systems. The concept of the Agricultural Research Implementation Gap (ARIG) is introduced to describe the gap between the ambition embodied in continental policy commitments and the scientific and institutional capacity available for effective implementation.

3.2 Evolution of Africa's Continental Agricultural Development Agenda

Africa's agricultural development agenda has evolved through successive policy frameworks, each expanding the scope of transformation and raising expectations for research and innovation.

The first major milestone was the Comprehensive Africa Agriculture Development Program (CAADP), adopted under the Maputo Declaration (2003). CAADP repositioned agriculture as a driver of economic growth by encouraging Member States to allocate at least 10% of public expenditure to agriculture and to achieve 6% annual agricultural growth, while promoting evidence-based planning, investment, and regional cooperation (African Union, 2003).

The Malabo Declaration (2014) enhanced accountability by introducing measurable commitments to end hunger, reduce poverty through agriculture by half, strengthen resilience, expand intra-African trade, and monitor progress through the Biennial Review process (African Union, 2014). This review mechanism has since become one of the world's most comprehensive agricultural performance assessment systems.

Building on these experiences, the Kampala Declaration (2025) expanded the focus from agricultural production to sustainable food-system transformation. It emphasizes nutrition, youth and women's empowerment, climate resilience, digital agriculture, private-sector participation, sustainable financing, and evidence-based policymaking. The accompanying Kampala Strategy and Action Plan (2026–2035) explicitly recognizes science, technology, and innovation as central drivers of agricultural transformation and calls for stronger National Agricultural Research Systems as strategic national assets (African Union, 2025).

Collectively, these frameworks demonstrate a clear evolution from production-focused policies toward integrated food systems that depend on continuous knowledge generation, technological innovation, and adaptive research. Successful implementation fundamentally relies on research systems capable of translating continental commitments into practical national solutions.

Table 3.1. Evolution of Africa's Continental Agricultural Development Agenda and the Changing Role of Agricultural Research

Continental Framework	Primary Development Focus	Evolution of the Role of Agricultural Research
Agenda 2063	Inclusive economic transformation	Research drives industrialization, competitiveness, human capital, and knowledge economies.
Maputo Declaration (2003)	Agricultural growth and public investment	Technology generation to increase productivity and food production.
Malabo Declaration (2014)	Results-based agricultural transformation	Research supports innovation, monitoring, resilience, value chains, and accountability.
Kampala Declaration (2025)	Food systems transformation and resilience	Research becomes the knowledge engine for policy implementation, innovation, digital agriculture, climate adaptation, and private-sector development.
STISA-2034	Science, technology and innovation-led development	Agricultural research becomes part of national innovation ecosystems linking science, entrepreneurship, AI, biotechnology, and commercialization.
SIA and AFSH-AP	Soil health restoration	Research provides soil diagnostics, digital soil information, nutrient management technologies, and long-term monitoring systems.
SDGs and Climate Agenda	Sustainable development	Research integrates agriculture, nutrition, climate adaptation, biodiversity, and circular bioeconomy.

Table 3.1 demonstrates that agricultural research has evolved from a narrow mandate of technology generation to a far broader role as an integrator of science, innovation, policy, and sustainable development. Consequently, research organizations are no longer expected merely to develop improved crop varieties or livestock breeds; they are increasingly called upon to provide strategic intelligence, evidence-based policy advice, digital information systems, innovation platforms, and scientific leadership for national development.

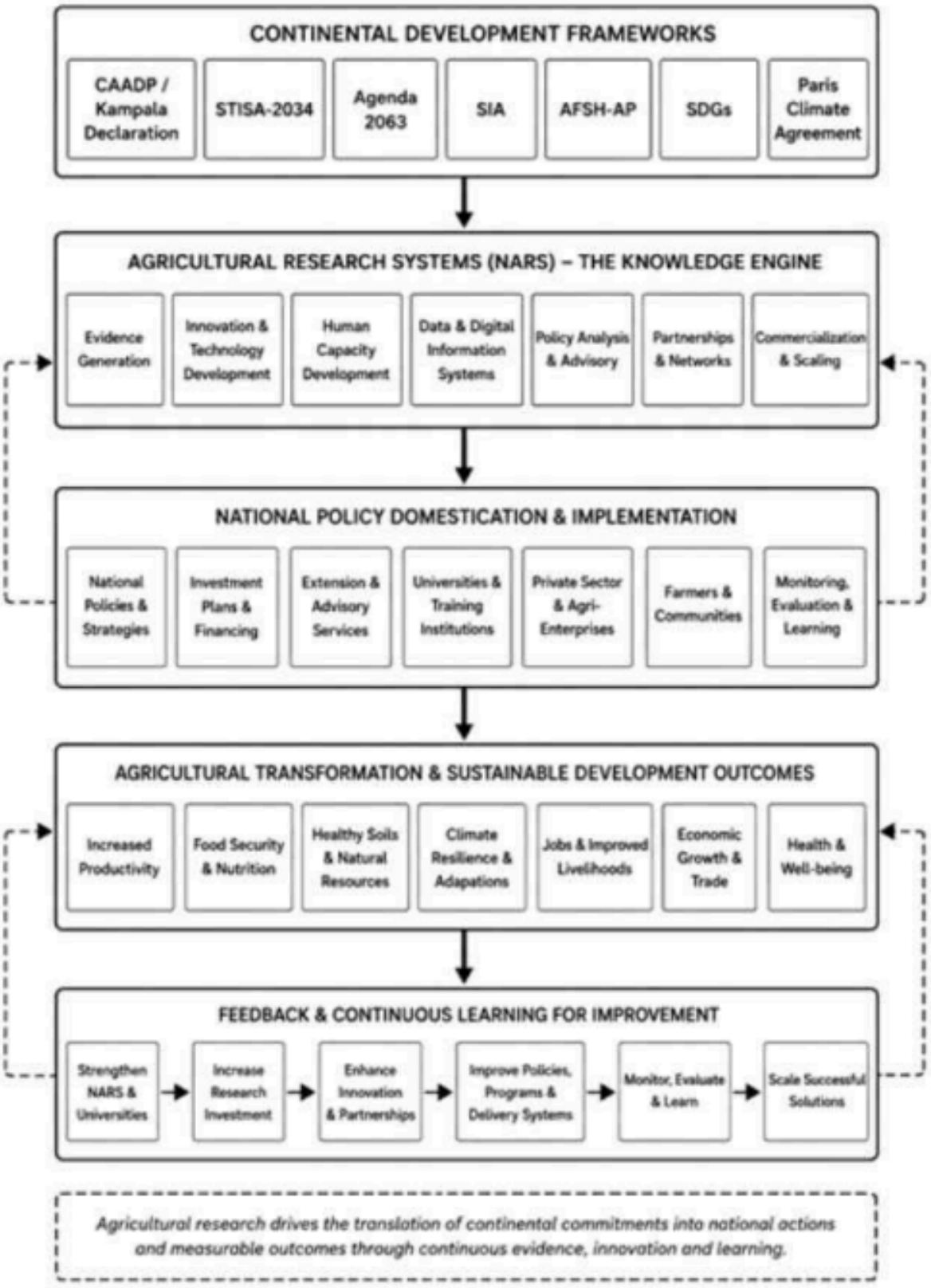


Figure 3.1. Agricultural Research as the Knowledge Engine for Africa's Development Agenda (Conceptual Framework)

Figure 3.1 illustrates the central proposition of this chapter: continental frameworks establish strategic direction, but it is agricultural research that converts these aspirations into implementable national Programs and measurable development outcomes.

3.3 STISA-2034: Repositioning Science, Technology and Innovation for Agricultural Transformation

The adoption of the Science, Technology and Innovation Strategy for Africa (STISA-2034) represents a major shift in Africa's science policy. Building on STISA-2024, the new strategy identifies science, technology, innovation, and knowledge as key drivers for implementing Agenda 2063 and advancing Africa's transition to a competitive, knowledge-based economy (African Union Commission [AUC], 2025).

Unlike earlier science policies focused mainly on research outputs, STISA-2034 takes a mission-oriented approach. It emphasizes applying science to address societal challenges and promote industrialization, entrepreneurship, digital transformation, environmental sustainability, and economic competitiveness. Agriculture is central to this vision, as food systems support nutrition, employment, climate resilience, biodiversity conservation, public health, and rural development.

The strategy prioritizes strengthening national research and innovation systems, modernizing research infrastructure, and promoting frontier technologies, including artificial intelligence, biotechnology, remote sensing, robotics, and digital platforms. It also focuses on enhancing technology commercialization, improving scientific mobility, and strengthening science-policy linkages. These priorities shift agricultural research from a traditional public research function to an integrated innovation ecosystem that generates economic and social value.

For National Agricultural Research Systems (NARS), STISA-2034 brings both opportunities and new responsibilities. Research institutions are expected to move from isolated centers of experimentation to innovation hubs that connect universities, government, extension services, private enterprises, financial institutions, farmer organizations, and development partners. Success will be measured not only by scientific outputs but also by contributions to technology adoption, enterprise development, employment, environmental sustainability, and evidence-based policymaking.

The strategy also emphasizes commercialization and digital transformation. By strengthening intellectual property management, innovation incubators, technology transfer, and partnerships with agribusiness, STISA-2034 aims to accelerate the commercialization of research-based innovations. Advances in artificial intelligence, precision agriculture, genomics, big data, climate modeling, and geospatial technologies are also reshaping agricultural research and improving its ability to address emerging challenges.

Ultimately, STISA-2034 elevates agricultural research from a supporting activity to a strategic pillar of Africa's knowledge economy. Strengthening agricultural research is therefore an investment not only in agriculture but also in innovation, industrial competitiveness, and sustainable economic transformation.

Knowledge-driven development	Evidence-based agricultural transformation	Generate scientific evidence for policy and investment decisions
National innovation ecosystems	Stronger collaboration across institutions	Coordinate universities, extension, private sector and farmers
Frontier technologies (AI, biotechnology, digitalization)	Precision agriculture and smart farming	Develop and adapt emerging technologies for African conditions
Human capital development	Next generation of agricultural scientists	Strengthen postgraduate training and research mentorship
Research commercialization	Increased private-sector participation	Promote technology transfer, incubation and agribusiness partnerships
Science-policy interface	Better policy implementation	Provide scientific advice, foresight and policy evaluation
Regional scientific collaboration	Shared continental solutions	Promote collaborative research through regional and continental networks

STISA-2034 therefore provides the scientific architecture through which agricultural research can support Africa's broader development agenda.

3.4 Agenda 2063: Agricultural Research and Africa's Knowledge Economy

Agenda 2063 articulates Africa's long-term vision for inclusive growth, sustainable development, regional integration, and global competitiveness (African Union Commission, 2015). The framework identifies agriculture as a strategic economic sector with the potential to drive industrialization, food security, environmental sustainability, and structural transformation, rather than viewing it solely as a subsistence activity.

A core component of this vision is the understanding that agricultural transformation relies on science, technology, and innovation. Agricultural research drives progress in crop and livestock productivity, mechanization, biotechnology, irrigation, digital agriculture, climate adaptation, post-harvest technologies, and value addition. Furthermore, it supports the development of universities, innovation hubs, digital infrastructure, and scientific leadership necessary for a knowledge-based economy.

The implementation of the African Continental Free Trade Area (AfCFTA) underscores the importance of research by necessitating harmonized standards, competitive value chains, evidence-based trade policies, and climate-resilient production systems. Consequently, Agenda 2063 positions agricultural research as a strategic driver of industrialization, regional integration, and economic diversification.

Box 3.4. Agricultural Research as an Enabler of the African Continental Free Trade Area (AfCFTA)

The African Continental Free Trade Area (AfCFTA) presents an unprecedented opportunity to expand intra-African trade in agricultural commodities, agro-industrial products, technologies, and knowledge. However, the realization of this opportunity depends not only on market liberalization but also on the harmonization of technical regulations that govern agricultural trade across national borders.

Despite growing regional integration, differences in sanitary and phytosanitary (SPS) measures, food safety regulations, seed certification systems, pesticide standards, veterinary requirements, quality assurance protocols, and conformity assessment procedures continue to create significant technical barriers to trade. These regulatory inconsistencies increase transaction costs, delay market access, and disproportionately affect smallholder farmers, women entrepreneurs, and small and medium-sized agribusinesses seeking to participate in regional value chains.

To unlock the full potential of the AfCFTA, regional agricultural research and innovation systems must actively support the harmonization of sanitary and phytosanitary (SPS) measures and the standardization of regional agrifood regulations. Sub-Regional Organizations (SROs), working in collaboration with National Agricultural Research Systems (NARS), Regional Economic Communities (RECs), standards organizations, and regulatory agencies, should lead the development of science-based, green, and gender-inclusive trade guidelines that simplify compliance for cross-border smallholder traders while reducing technical barriers to trade.

Agricultural research institutions have a critical role in generating the scientific evidence required to underpin harmonized standards, including food safety risk assessments, pest and disease surveillance, seed quality assurance, climate-smart production protocols, traceability systems, residue monitoring, and digital certification mechanisms. Research can also support the development of interoperable digital platforms that facilitate regional certification, product traceability, and mutual recognition of conformity assessments.

By strengthening regulatory science and promoting evidence-based policy harmonization, Africa's agricultural research systems can move beyond technology generation to become strategic enablers of regional market integration, competitiveness, and food system resilience. Such investments will help transform the AfCFTA from a trade agreement into a catalyst for agricultural industrialization, inclusive economic growth, and continental food security.

3.5 Agricultural Research within the Soil Initiative for Africa (SIA) and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP)

Declining soil health in Africa, resulting from nutrient depletion, erosion, loss of organic matter, salinization, and unsustainable land management, led to the adoption of the Soil Initiative for Africa (SIA) and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) in 2024 (African Union Commission, 2024). These frameworks seek to restore soil productivity through improved governance, harmonized policies, integrated soil fertility management, digital soil information systems, sustainable fertilizer use, and evidence-based decision-making.

Agricultural research is essential for the implementation of these initiatives. National Agricultural Research Systems are tasked with conducting soil characterization, nutrient response trials, digital soil mapping, fertilizer recommendation development, long-term monitoring, and validation of regenerative agricultural practices. Additionally, research generates the evidence necessary to monitor progress and inform national soil policies.

Healthy soils enhance fertilizer efficiency, water-use productivity, biodiversity, climate resilience, and carbon sequestration. However, implementation is hindered by inadequate laboratory infrastructure, fragmented soil databases, shortages of soil scientists, weak extension systems, and limited domestic investment. Strengthening soil research capacity is therefore critical for translating continental commitments into measurable outcomes.

3.6 Agricultural Research and Africa's Climate Adaptation Commitments

Climate change represents a significant threat to African agriculture. Rising temperatures, erratic rainfall, droughts, floods, land degradation, and emerging pests continue to diminish productivity, even though Africa contributes less than 4% of global greenhouse gas emissions (IPCC, 2023). As a result, climate adaptation is now central to continental frameworks such as the Paris Agreement, Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), the AU Climate Change Strategy (2022–2032), and the CAADP Kampala Declaration.

Agricultural research advances these commitments by developing climate-resilient crop varieties, improved livestock systems, efficient irrigation technologies, climate-smart farming practices, digital advisory services, and weather-informed decision-support tools. Progress in artificial intelligence, remote sensing, geographic information systems, and climate modeling further enhances adaptation planning and risk management.

In addition to technology development, research institutions increasingly assist governments with climate-risk assessment, greenhouse gas accounting, and monitoring adaptation investments. Robust National Agricultural Research Systems are therefore indispensable for building resilient food systems in the context of changing climatic conditions.

3.7 Agricultural Research within the Sustainable Development Goals and the Food Systems Agenda

The 2030 Agenda for Sustainable Development has significantly expanded the role of agricultural research. In addition to increasing production, research now directly contributes to poverty reduction, nutrition, health, environmental sustainability, employment, gender equality, and climate resilience (United Nations, 2015).

Agricultural research advances SDG 2 (Zero Hunger) by developing improved crop varieties, livestock breeds, soil fertility management, and sustainable farming systems. It also contributes to SDGs 1, 3, 5, 8, 12, 13, and 15 by increasing incomes, improving nutrition, promoting sustainable production, creating employment, strengthening climate resilience, and restoring ecosystems.

The United Nations Food Systems Summit (2021) shifted the focus from agricultural production to comprehensive food systems. Contemporary agricultural research must therefore address production, processing, nutrition, markets, environmental sustainability, waste management, and the circular bioeconomy. This transition necessitates multidisciplinary research and stronger National Agricultural Research Systems capable of generating integrated solutions to complex societal challenges.

Table 3.3. Contributions of Agricultural Research to Africa's Continental Development Agenda

Continental Framework	Major Development Objective	Key Contributions of Agricultural Research
CAADP-Kampala	Food systems transformation	Productivity enhancement, innovation, policy analysis, monitoring and evaluation
STISA-2034	Knowledge-driven development	Scientific innovation, technology commercialization, AI, digital agriculture, biotechnology
Agenda 2063	Inclusive economic transformation	Industrialization, value addition, human capital development, regional competitiveness
SIA	Sustainable soil management	Soil mapping, soil diagnostics, digital soil information systems, land restoration
AFSH-AP	Improved soil fertility	Fertilizer recommendations, nutrient management, integrated soil fertility technologies
Paris Agreement	Climate resilience	Climate-smart agriculture, adaptation technologies, carbon management, climate information services
SDGs	Sustainable development	Food security, nutrition, biodiversity conservation, sustainable production systems

Table 3.3 demonstrates that agricultural research is the only sector that contributes directly to the implementation of virtually every continental agricultural policy framework.

3.8 The Agricultural Research Implementation Gap (ARIG): A Conceptual Framework

Although Africa has developed one of the world's most comprehensive agricultural policy architectures, implementation has generally lagged behind ambition. The Fourth CAADP Biennial Review revealed that **no African Union Member State was on track to achieve all the Malabo Declaration commitments by 2025**, despite measurable progress in several countries (African Union Commission, 2024). Likewise, many countries remain off track to achieve SDG 2 on ending hunger, while soil degradation, low agricultural productivity, and climate vulnerability continue to constrain agricultural transformation (FAO et al., 2024).

Traditional explanations for these implementation gaps frequently emphasize inadequate financing, weak governance, political instability, climate shocks, or limited institutional coordination. While these factors are undoubtedly important, they do not fully explain why countries with similar policy commitments often experience markedly different implementation outcomes.

This chapter proposes the concept of the **Agricultural Research Implementation Gap (ARIG)** as an additional explanatory framework.

Definition

The Agricultural Research Implementation Gap (ARIG) is the difference between the ambition embodied in continental agricultural policy commitments and the scientific capacity of national research and innovation systems to generate the evidence, technologies, human capital, and institutional support required for effective implementation.

The concept recognizes that policies themselves do not generate development outcomes. Rather, implementation depends on the ability of national institutions to convert policy objectives into technologies, innovations, investment priorities, extension recommendations, monitoring systems, and evidence-based decision-making.

Countries with stronger research systems generally possess greater capacity to domesticate continental frameworks because they can rapidly generate locally adapted technologies, evaluate policy options, train skilled professionals, and provide continuous scientific support throughout implementation. Conversely, weak research systems often lead to delayed technology development, limited uptake of innovation, inadequate policy evidence, weak monitoring systems, and poor coordination among stakeholders.

The ARIG framework therefore shifts attention from the quality of policy design to the capacity for policy implementation. Closing this gap requires sustained investments in National Agricultural Research Systems, universities, scientific infrastructure, digital information systems, and innovation partnerships.

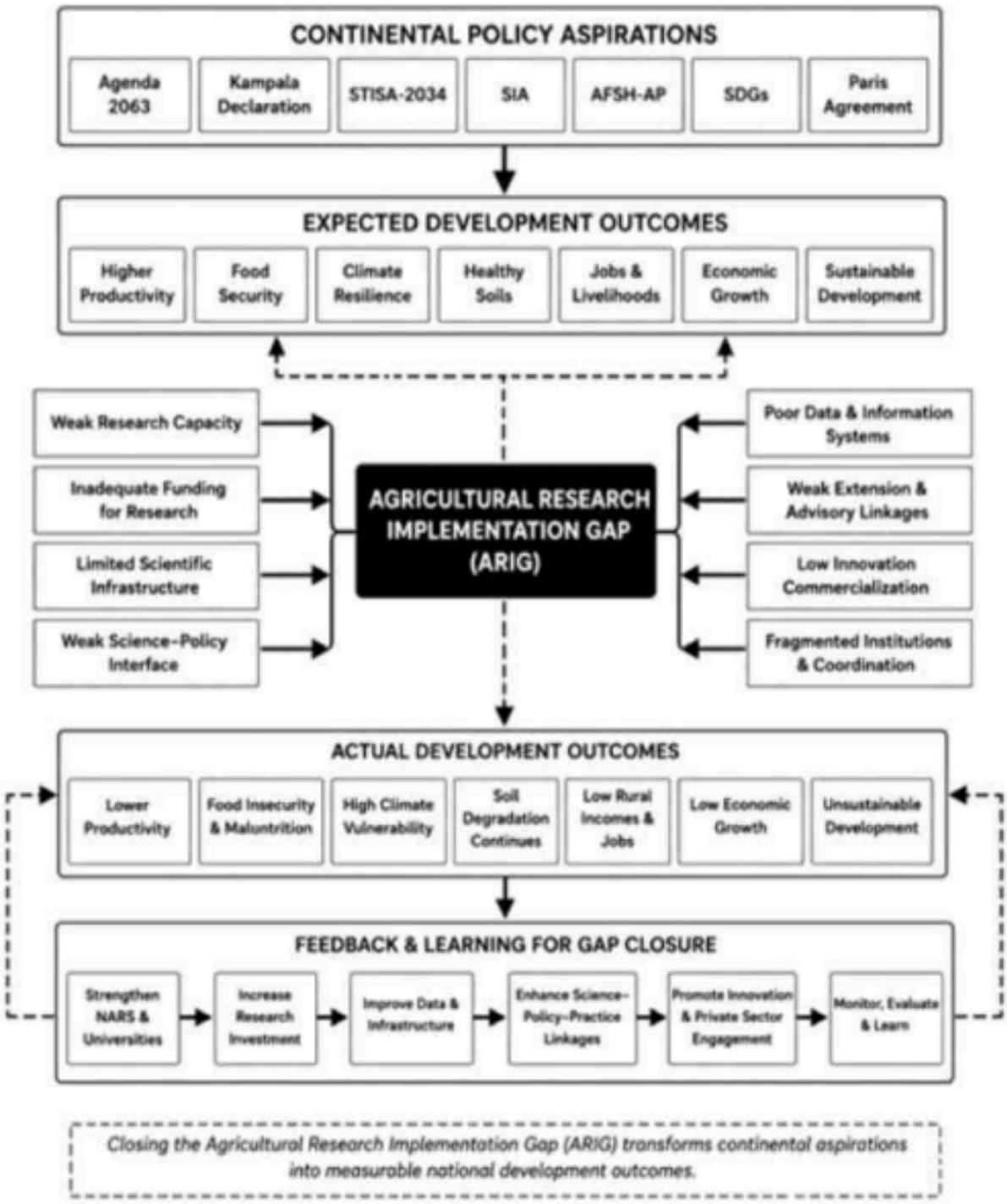


Figure 3.2. The Agricultural Research Implementation Gap (ARIG)

Figure 3.2 illustrates that the principal barrier between continental aspirations and national outcomes is frequently not the absence of policy, but the limited scientific capacity required for effective implementation

3.9 Towards a Research-Led Model of Continental Policy Domestication

The growing number of continental frameworks adopted by the African Union presents an unprecedented opportunity for agricultural transformation. However, these commitments should not be viewed as independent initiatives competing for national attention. Rather, they represent complementary components of a single continental development architecture, all requiring a common implementation platform.

National Agricultural Research Systems provide that platform.
Research institutions occupy a unique position because they simultaneously generate scientific knowledge, develop technologies, build human capacity, support evidence-based policymaking, strengthen innovation systems, and evaluate development outcomes. No other institution performs all these functions simultaneously.

Consequently, the effectiveness of Africa's continental development agenda increasingly depends upon the strength of its national research systems. Strengthening NARS should therefore be regarded not merely as an agricultural investment but as a strategic investment in national implementation capacity. This chapter advances the following proposition:

Evidence Box
Continental agricultural declaration can outperform the scientific capacity of the national institutions responsible for its implementation. Therefore, strengthening National Agricultural Research Systems is one of the most effective investments African countries can make to domesticate continental commitments and accelerate agricultural transformation.
This proposition establishes agricultural research as the knowledge engine connecting continental vision to national development outcomes.

3.10 Repositioning National Agricultural Research Systems for Continental Policy Domestication

The analysis presented in this chapter demonstrates that Africa has developed an extensive architecture of continental policies, declarations, and strategic frameworks to accelerate agricultural transformation. Collectively, these instruments articulate a shared vision of productive, resilient, inclusive, and sustainable food systems. However, their success ultimately depends on the capacity of individual Member States to translate continental aspirations into nationally owned policies, investments, technologies, and institutional reforms.

National Agricultural Research Systems (NARS) occupy a unique position within this implementation landscape. Unlike sector ministries that formulate policies or extension agencies that disseminate technologies, NARS integrates multiple functions that are indispensable for policy domestication. These include generating scientific evidence, developing locally adapted technologies, strengthening human capital, informing policy decisions, supporting innovation, and monitoring implementation outcomes. Consequently, the effectiveness of virtually every continental agricultural commitment depends upon the strength and responsiveness of national research institutions.

To fulfill this role, many NARS require significant institutional transformation. Historically, numerous research organizations have concentrated primarily on commodity improvement and scientific publications. Contemporary development challenges demand a broader mandate in which research institutions function as national knowledge platforms that coordinate multidisciplinary innovation, facilitate science–policy dialogue, strengthen public–private partnerships, and provide strategic foresight for governments. This shift requires stronger leadership, improved governance, modern

research infrastructure, enhanced digital capabilities, and closer collaboration with universities, extension services, farmer organizations, and the private sector.

Equally important is the need to reposition research financing. Although external development partners have made significant contributions to agricultural research over the past five decades, excessive dependence on donor funding has often resulted in fragmented priorities and discontinuity of research Programs. Sustainable domestication of continental commitments requires predictable domestic financing that enables NARS to address nationally defined priorities while responding to emerging regional and global challenges. Agricultural research should therefore be regarded as a long-term public investment in national competitiveness rather than a discretionary expenditure.

The successful implementation of the Kampala Declaration, STISA-2034, Agenda 2063, the Soil Initiative for Africa, the Africa Fertilizer and Soil Health Action Plan, and Africa's climate commitments will depend increasingly on countries' ability to establish robust research-policy interfaces. Governments should institutionalize mechanisms through which researchers participate in policy formulation, implementation planning, monitoring, and evaluation. Such arrangements will improve evidence-based decision-making while ensuring that national policies remain responsive to emerging scientific knowledge.

Table 3.4. Strategic Actions for Strengthening National Agricultural Research Systems

Strategic Priority	Recommended Actions	Expected Contribution to Policy Domestication
Sustainable Financing	Increase domestic investment in agriculture and establish competitive national research funds.	Greater ownership and continuity of research programs
Human Capital Development	Recruit, train, and retain young scientists; strengthen postgraduate education and mentorship	Improved scientific leadership and long-term research capacity
Modern Research Infrastructure	Upgrade laboratories, research farms, digital platforms, and analytical facilities	Higher quality research and faster technology development
Science–Policy Interface	Institutionalize advisory mechanisms linking researchers with policymakers.	Stronger evidence-based planning and implementation
Innovation Partnerships	Strengthening collaboration among NARS, universities, CGIAR centers, extension, private sector, and farmers.	Faster scaling of innovations and improved adoption
Digital Transformation	Invest in AI, geospatial technologies, digital information systems, and data analytics.	Enhanced monitoring, forecasting, and precision decision-making
Knowledge Management	Strengthen monitoring, evaluation, learning and open-access knowledge systems.	Improved accountability and continuous policy improvement

3.11 Conclusion

Over the past two decades, Africa has developed an ambitious portfolio of continental frameworks, including CAADP, the Kampala Declaration, Agenda 2063, STISA-2034, the Soil Initiative for Africa (SIA), the Africa Fertilizer and Soil Health Action Plan (AFSH-AP), and the Sustainable Development Goals to accelerate agricultural transformation. Together, these initiatives provide a coherent vision for achieving food security, climate resilience, sustainable natural resource management, and inclusive economic growth.

However, policies alone cannot transform agriculture. Their success depends on countries' ability to generate the scientific knowledge, technologies, human capacity, and institutional arrangements needed for effective implementation. This chapter has argued that National Agricultural Research Systems (NARS) provide this implementation capacity by translating continental aspirations into nationally relevant technologies, evidence, and innovation. It introduced the concept of the Agricultural Research Implementation Gap (ARIG) to explain the disconnect between ambitious policy commitments and development outcomes. The chapter shows that this gap reflects not only financial and governance constraints but also the limited capacity of research and innovation systems to support policy implementation.

Bridging the ARIG requires repositioning NARS as strategic national assets rather than institutions concerned solely with scientific research. Governments should strengthen domestic financing, modernize research infrastructure, enhance science-policy interfaces, promote multidisciplinary collaboration, accelerate digital transformation, and build stronger partnerships with universities, extension services, the private sector, and farmer organizations.

Ultimately, Africa's agricultural future will depend less on the number of declarations adopted than on the continent's capacity to implement them. Strong, well-funded, and innovation-driven National Agricultural Research Systems will determine whether continental commitments become measurable gains in productivity, food security, climate resilience, healthy soils, and economic transformation. Investing in agricultural research is therefore an investment in Africa's ability to convert vision into lasting development.

CHAPTER 4

Institutional Architecture of Africa's Agricultural Research and Innovation System

Summary

This chapter examines the institutional architecture that underpins Africa's agricultural research and innovation system, highlighting the complementary roles of National Agricultural Research Systems (NARS), universities, CGIAR centres, Sub-Regional Organizations (CORAF, ASARECA, CCARDESA, and NASRO), the Forum for Agricultural Research in Africa (FARA), private-sector research organizations, and emerging innovation ecosystems. It argues that Africa's agricultural transformation depends less on the strength of individual institutions than on the quality of collaboration, coordination, and knowledge exchange among them. The chapter positions FARA as the continent's coordinating mechanism for agricultural research and innovation, while emphasizing Agricultural Innovation Systems as the organizational framework through which research, education, policy, private enterprise, and farmers jointly generate, adapt, and scale innovations that support food security, climate resilience, and sustainable development.

4.1 Introduction

Agricultural transformation is primarily an institutional process. Although scientific research produces new knowledge and technologies, their effectiveness relies on institutions that foster innovation, build human capacity, mobilize partnerships, disseminate technologies, and inform public policy. Countries including Brazil, China, India, and the Republic of Korea have transformed their agricultural sectors through integrated research and innovation systems marked by robust institutions, sustained investment, effective coordination, and strong linkages among research, education, extension, and the private sector (World Bank, 2012; OECD, 2015).

The agricultural research landscape in Africa has developed into a multi-level system that includes national, regional, continental, and international institutions. National Agricultural Research Systems (NARS) continue to serve as the primary sources of agricultural technologies and scientific guidance. Universities contribute through education, research, and innovation, while extension services support the dissemination of technology. Regional organizations coordinate cross-border research, international centers offer advanced scientific expertise, and continental organizations facilitate policy coordination, knowledge management, and institutional strengthening.

The growing complexity of agriculture, encompassing climate change, soil health, nutrition, digital agriculture, mechanization, biotechnology, agribusiness, and sustainable food systems, indicates that no single institution can address these challenges alone. Consequently, effective agricultural transformation relies on collaboration among research institutes, universities, governments, private enterprises, farmer organizations, and development partners.

The Agricultural Innovation Systems (AIS) framework offers a valuable perspective for analyzing these interactions. Instead of conceptualizing innovation as a linear transfer of technology from researchers to farmers, AIS views it as a collaborative process in which multiple actors jointly generate, adapt, and apply knowledge (Hall et al., 2006; World Bank, 2012).

This chapter analyzes the institutional architecture that supports agricultural research and innovation in Africa, emphasizing the complementary roles of NARS, universities, CGIAR centers, Sub-Regional Organizations (SROs), the Forum for Agricultural Research in Africa (FARA), private-sector research organizations, and emerging innovation platforms. It contends that Africa's agricultural transformation relies not only on robust institutions but also on effective coordination, partnership, and knowledge exchange throughout the agricultural innovation ecosystem.

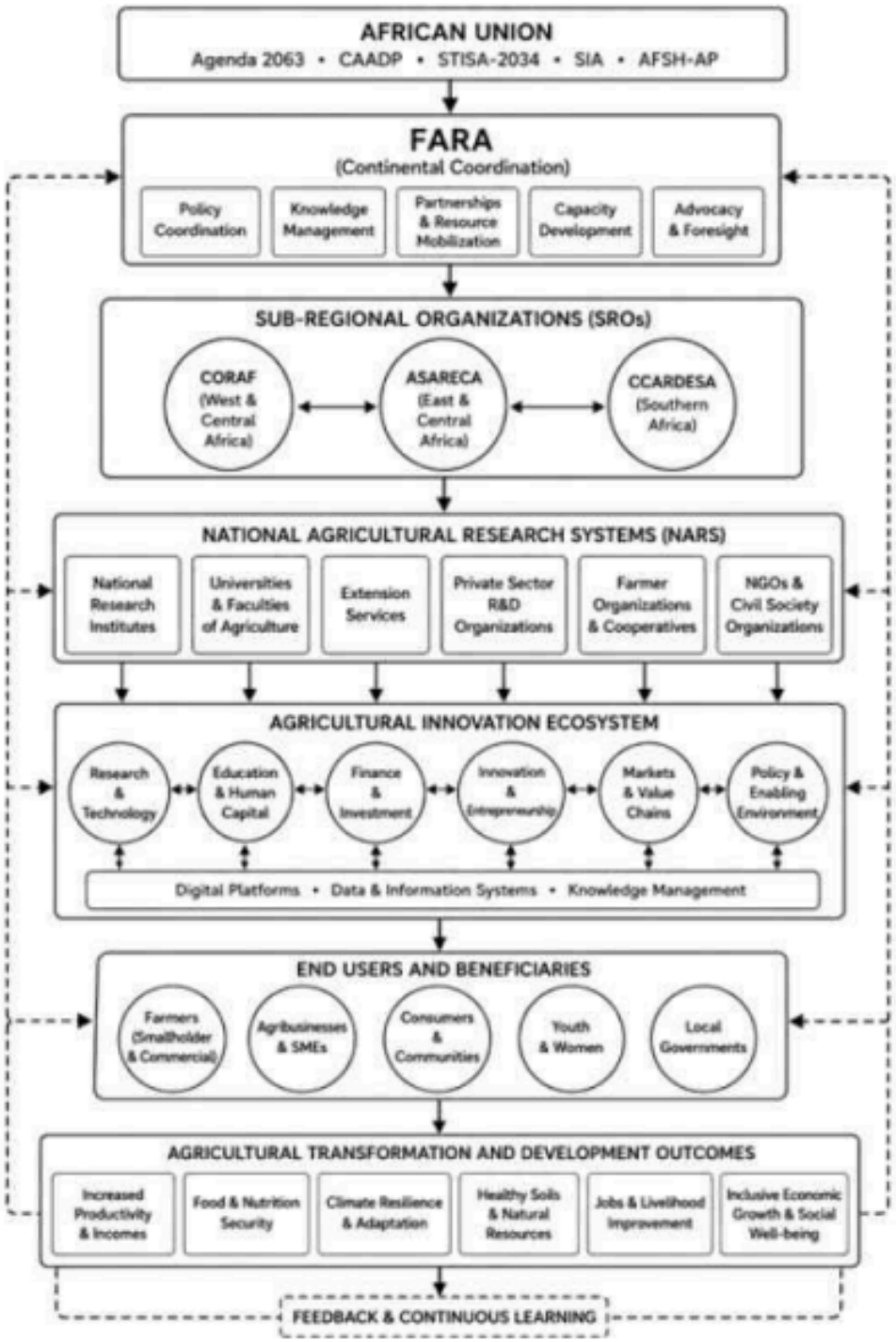


Figure 4.1. Institutional Architecture of Africa's Agricultural Research and Innovation System

4.2 National Agricultural Research Systems (NARS): The Foundation of Agricultural Innovation

National Agricultural Research Systems (NARS) constitute the foundation of Africa's agricultural research architecture. Introduced in the 1980s, the NARS concept acknowledges that agricultural research encompasses not only government institutes but also universities, extension services, private companies, civil society, farmer organizations, and other entities engaged in generating and applying agricultural knowledge (ISNAR, 1992). Currently, NARS functions as the principal scientific platform for technology development, policy support, and the domestication of continental and global agricultural commitments.

Most African NARS originated from colonial agricultural departments established to support export-commodity production. After independence, these entities expanded into national research organizations responsible for crop and livestock improvement, fisheries, forestry, natural resource management, agricultural engineering, and socio-economic research. Despite reductions in public investment and increased reliance on donor funding due to structural adjustment programs in the 1980s and 1990s, many NARS continued to develop improved crop varieties, livestock technologies, integrated pest management practices, and natural resource management innovations that made significant contributions to agricultural development (Pardey et al., 2016).

Currently, NARS engages in a broad range of activities beyond technology generation. These include conducting strategic and adaptive research, providing scientific evidence for policymaking, conserving germplasm resources, strengthening food safety systems, developing climate-smart technologies, and supporting postgraduate training. Additionally, NARS increasingly delivers digital advisory services, geospatial analysis, climate information, and monitoring systems that facilitate the implementation of continental initiatives such as the Kampala Declaration, the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP).

Despite these advancements, many NARS continue to experience inadequate funding, aging infrastructure, limited laboratory capacity, shortages of highly qualified scientists, and insufficient operational resources. Furthermore, weak collaboration with universities, extension services, and the private sector constrains the dissemination and commercialization of technologies.

Future reforms should reposition NARS as national innovation platforms instead of traditional research institutes. Achieving this transformation will require multidisciplinary research, digitalization, enhanced science-policy engagement, entrepreneurship, foresight, and public-private partnerships, supported by closer collaboration with universities, farmer organizations, agribusinesses, and international research institutions. These reforms will better equip NARS to address emerging challenges such as climate change, biodiversity conservation, food system transformation, and digital agriculture.

Table 4.1. Core Functions of National Agricultural Research Systems

Core Function	Principal Activities	Expected Development Outcomes
Strategic Research	Basic and applied research, technology generation	Increased productivity and resilience
Adaptive Research	Multi-location trials, farmer participatory research	Locally adapted technologies
Policy Research	Economic analysis, policy evaluation, foresight	Evidence-based policymaking
Human Capacity Development	Postgraduate training, mentoring, professional development	Skilled scientific workforce
Knowledge Management	Publications, databases, digital platforms, open science	Improved access to scientific knowledge
Innovation Partnerships	Collaboration with universities, CGIAR, extension and private sector	Accelerated technology dissemination and commercialization
Monitoring and Evaluation	Impact assessment, data systems, performance monitoring	Improved accountability and learning

The expanding mandate of NARS reflects the broader evolution of agricultural research from a technology-focused activity to a knowledge-driven system supporting national development. Their effectiveness increasingly depends on the strength of partnerships with complementary institutions across the agricultural innovation ecosystem rather than on their individual scientific capacity alone.

4.3 Universities and Faculties of Agriculture: Advancing Africa's Scientific Capacity

Universities constitute the intellectual foundation of Africa's agricultural research and innovation system. While National Agricultural Research Systems (NARS) generate technologies and offer scientific support for development, universities are tasked with developing human capital, advancing scientific discovery, fostering innovation, and preparing future agricultural leaders. Collectively, these institutions supply the scientific workforce necessary to implement Africa's agricultural transformation agenda.

Initially established to train agricultural officers and extension personnel, African Faculties of Agriculture have developed into comprehensive centers for teaching, research, policy analysis, and community engagement. Currently, over **500 African universities** offer programs in agriculture and natural resources, producing graduates in agronomy, animal science, agricultural engineering, soil science, biotechnology, food science, agricultural economics, forestry, fisheries, and related disciplines (RUFORUM, 2024).

Universities have also emerged as significant research institutions, hosting Centres of Excellence, biotechnology laboratories, climate research centers, innovation hubs, and digital agriculture facilities. Through collaboration with NARS, CGIAR centers, regional organizations, and development partners, these universities contribute substantially to scientific publications, technology development, policy research, and multidisciplinary innovation that integrates agriculture with engineering, environmental sciences, economics, health sciences, and information technology.

Continental networks, including the **Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)** and the **African Research Universities Alliance (ARUA), have enhanced** postgraduate training, staff mobility, curriculum harmonization, and collaborative research, thereby strengthening Africa's scientific capacity.

Despite these advancements, universities continue to encounter inadequate research funding, outdated laboratories, limited access to modern equipment, weak industry linkages, and shortages of academic staff due to retirements and brain drain. In many instances, research outputs are insufficiently aligned with national development priorities, and underdeveloped commercialization systems constrain their broader impact.

To address these challenges, universities should transition into innovation-driven institutions by enhancing entrepreneurship, technology incubation, interdisciplinary research, private-sector partnerships, and the integration of digital technologies such as artificial intelligence, remote sensing, precision agriculture, and big data analytics. Strengthened collaboration with NARS will ensure that postgraduate research addresses national agricultural challenges directly. Within the Agricultural Innovation Systems framework, universities are increasingly recognized as centers of learning and as strategic partners in innovation, technology commercialization, policy development, and scientific leadership.

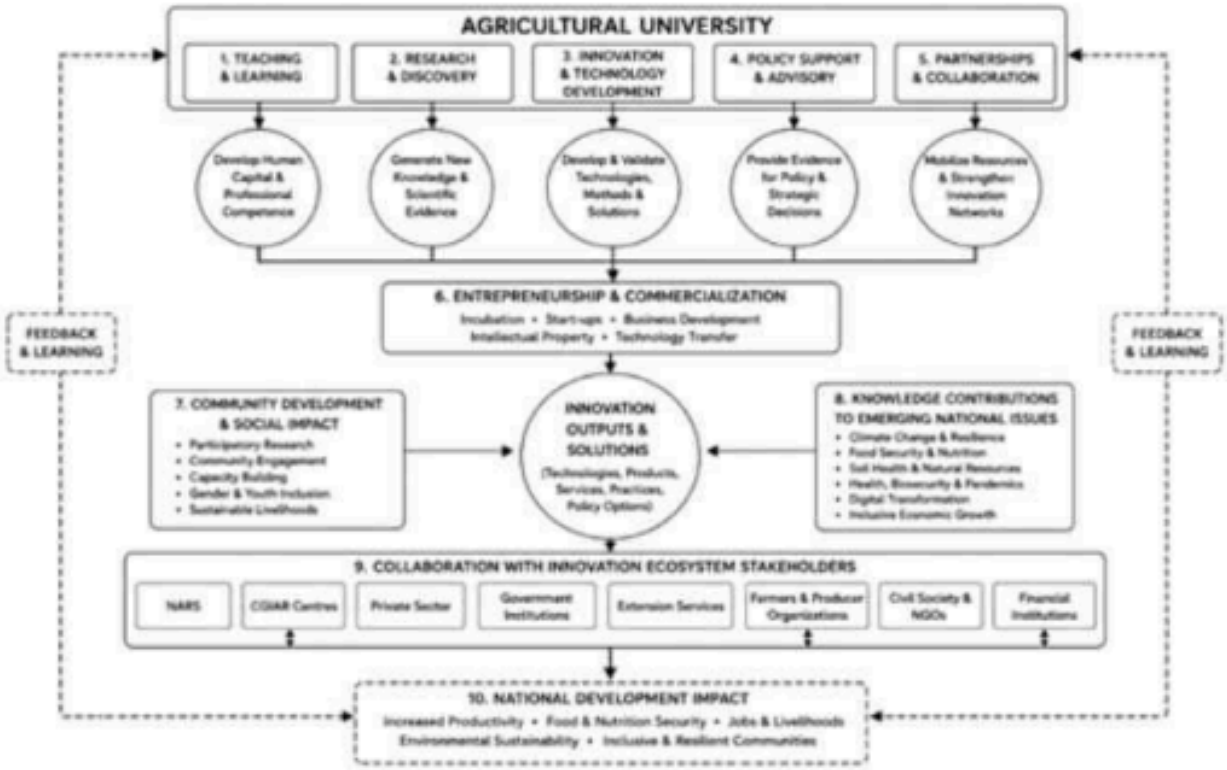


Figure 4.2. The Evolving Role of Agricultural Universities within Africa's Innovation System

The evolving role of universities reflects the broader transition from knowledge generation to innovation-driven development. Their effectiveness increasingly depends on strong partnerships with research organizations, governments, and industry.

4.4 CGIAR and International Agricultural Research Collaborations

International agricultural research has been instrumental in advancing Africa's agricultural development. Since its establishment in 1971, the Consultative Group on International Agricultural Research (CGIAR) has achieved significant progress in crop improvement, livestock production, natural resource management, climate adaptation, food systems, and agricultural policy. Through sustained partnerships with National Agricultural Research Systems (NARS), universities, governments, and regional organizations, CGIAR has become a central element of Africa's agricultural innovation ecosystem.

Several CGIAR centres collaborate with African partners, including the International Institute of Tropical Agriculture (IITA), International Livestock Research Institute (ILRI), International Maize and Wheat Improvement Center (CIMMYT), AfricaRice, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Water Management Institute (IWMI), International Potato Center (CIP), and the Alliance of Bioversity International and CIAT. These institutions have developed improved crop varieties, livestock technologies, climate-smart practices, digital decision-support tools, and policy innovations that have benefited millions of farmers across Africa.

In addition to technology development, CGIAR's most significant contribution is its partnership model. Through joint research, postgraduate training, laboratory support, germplasm exchange, and regional research networks, CGIAR has enhanced scientific capacity and facilitated access to global knowledge and advanced technologies. The recent CGIAR reform further promotes integrated research on climate resilience, nutrition, biodiversity, digital agriculture, and sustainable food systems, aligning with Africa's priorities as outlined in the Kampala Declaration, Agenda 2063, STISA-2034, and the Sustainable Development Goals.

Despite these achievements, several challenges persist. Donor-driven funding often shapes research priorities, and reliance on externally financed Programs may undermine national ownership. Furthermore, weak extension systems, limited private-sector engagement, and insufficient commercialization continue to hinder technology adoption.

Future partnerships should progress beyond technology transfer to emphasize the co-creation of innovation. National Agricultural Research Systems are encouraged to assume greater leadership in setting priorities, while CGIAR provides advanced scientific expertise, global research networks, and access to frontier technologies. These complementary partnerships will strengthen Africa's scientific capacity, enhance research sovereignty, and ensure sustained access to world-class agricultural research.

The CGIAR system remains an indispensable strategic partner within Africa's agricultural research architecture. However, maximizing its impact requires stronger alignment with national priorities, enhanced technology commercialization, and deeper institutional integration with NARS, universities, and the private sector.

4.5 Sub-Regional Organizations: Bridging National and Continental Agricultural Research

Africa's diverse agroecological zones, farming systems, and socio-economic conditions result in agricultural challenges such as climate change, transboundary pests and diseases, natural resource management, and regional food trade that extend beyond national borders. In response to these shared challenges, African governments established Sub-Regional Organizations (SROs) to enhance collaboration among National Agricultural Research Systems (NARS), coordinate regional research efforts, and generate regional public goods.

SROs address the fragmented nature of many national research systems. Given that several African countries possess limited scientific capacity and financial resources, regional collaboration allows for pooling of expertise, sharing of research infrastructure, harmonization of priorities, and accelerated dissemination of technology across similar agroecological zones.

Three principal SROs support Africa's agricultural research architecture: the West and Central African Council for Agricultural Research and Development (CORAF), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), and the Center for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA). Although each serves a distinct region, all three organizations promote collaborative research, foster innovation, harmonize policy, strengthen institutions, and support capacity development.

CORAF coordinates research and innovation across 23 West and Central African countries, focusing on climate-smart agriculture, resilient food systems, natural resource management, and regional technology dissemination. ASARECA enhances research partnerships, innovation platforms, and policy dialogue in Eastern and Central Africa, contributing to sustainable intensification and climate resilience. CCARDESA advances regional collaboration in Southern Africa, emphasizing climate adaptation, digital agriculture, sustainable natural resource management, and institutional strengthening.

Collectively, the SROs deliver regional public goods that individual countries cannot provide efficiently on their own. These include harmonized research protocols, regional technology platforms, shared germplasm, transboundary disease surveillance, climate information services, scientific networks, and postgraduate capacity-building programs. Such functions have become increasingly important for supporting regional integration under the African Continental Free Trade

Area (AfCTA). Despite notable achievements, SROs continue to encounter funding uncertainty, divergent national priorities, and uneven institutional capacities among member states. Nevertheless, they remain essential for strengthening regional scientific collaboration, minimizing research duplication, and accelerating agricultural innovation across Africa.

4.6 FARA: The Continental Coordinating Mechanism for Agricultural Research and Innovation

The increasing complexity of Africa's agricultural development agenda necessitated the creation of a continental institution to coordinate agricultural research across national and regional boundaries. National Agricultural Research Systems (NARS) primarily generate technologies, and Sub-Regional Organizations (SROs) coordinate regional programs; however, neither possesses a mandate to harmonize research priorities, strengthen partnerships, or provide strategic leadership at the continental level. Consequently, the Forum for Agricultural Research in Africa (FARA) was established in 2001 as the apex organization for coordinating agricultural research for development across Africa.

In contrast to NARS or CGIAR centers, FARA does not conduct research directly. Rather, it functions as a continental facilitator, convener, knowledge broker, and coordinator, connecting national, regional, continental, and international stakeholders within Africa's Agricultural Innovation System. Since its inception, FARA has played a central role in advancing the Comprehensive Africa Agriculture Development Program (CAADP) through initiatives such as the Framework for African Agricultural Productivity (FAAP), the Science Agenda for Agriculture in Africa (S3A), and the Integrated Agricultural Research for Development (IAR4D) approach. More recently, FARA continues to support the Kampala Declaration, the Soil Initiative for Africa (SIA), the Africa Fertilizer and Soil Health Action Plan (AFSH-AP), the African Union Soil Observatory (AUSO), and the Science and Partnerships for African Agriculture Conference (SPAC).

FARA's comparative advantage is demonstrated through five complementary functions. First, it aligns agricultural research with key continental frameworks, including Agenda 2063, CAADP, STISA-2034, and the Sustainable Development Goals. Second, it operates as a continental knowledge management platform by synthesizing evidence, promoting foresight, and supporting evidence-based policymaking. Third, FARA convenes partnerships among governments, research institutions, universities, SROs, Regional Economic Communities, CGIAR centers, the private sector, farmer organizations, and development partners. Fourth, it enhances institutional capacity through policy support, organizational development, digital transformation, monitoring and evaluation, and resource mobilization. Finally, FARA advocates for increased investment in agricultural research and strengthens science-policy dialogue across the continent.

FARA is increasingly expanding its role in digital agriculture, open science, innovation commercialization, and continental learning. However, its effectiveness relies on close collaboration with NARS, SROs, universities, CGIAR centers, Regional Economic Communities, and the African Union Commission. Rather than supplanting these institutions, FARA amplifies their collective impact by providing strategic coordination, fostering partnerships, and offering continental leadership.Z

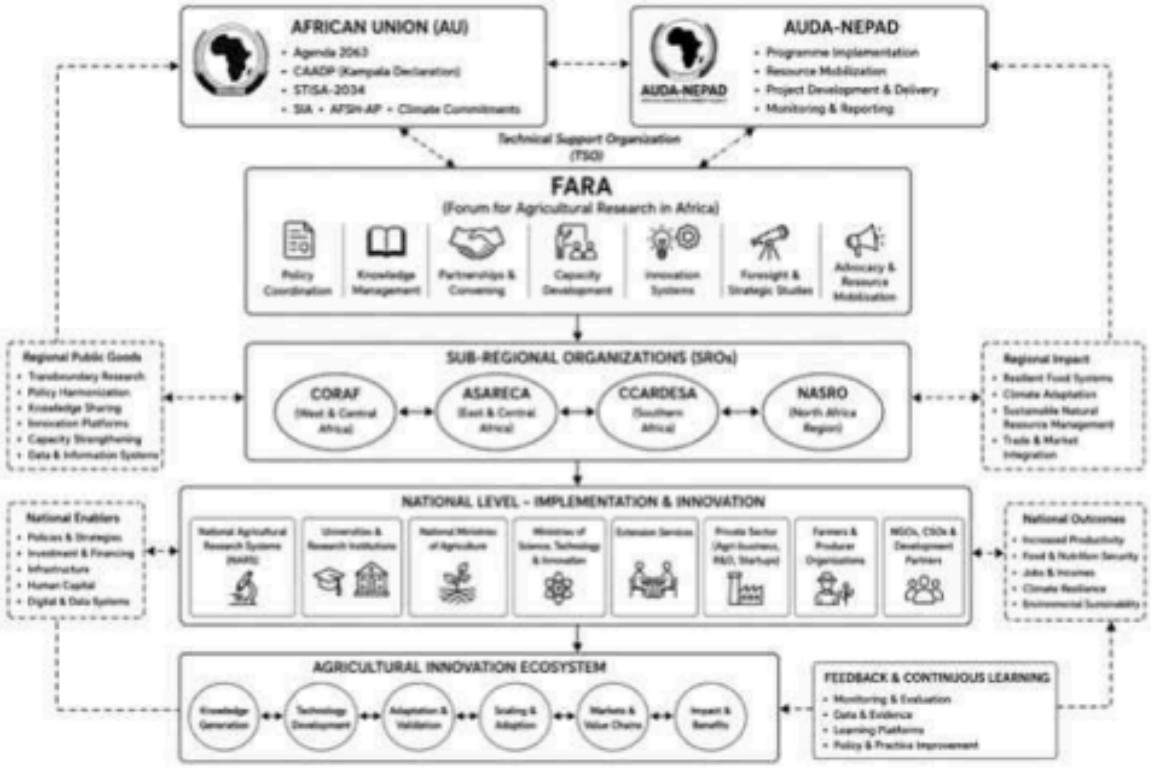


Figure 4.3. Africa's Multi-Level Agricultural Research Coordination Architecture

Institutional Complementarity within Africa's Agricultural Research System

The effectiveness of Africa's agricultural research architecture lies in the complementary mandates of its institutions rather than in institutional competition. National Agricultural Research Systems generate context-specific technologies and policy evidence; universities develop scientific talent and advance discovery; CGIAR centres contribute frontier science and global research networks; SROs coordinate regional collaboration and produce regional public goods; while FARA provides continental leadership, strategic coordination, and knowledge integration.

Together, these institutions constitute an interconnected Agricultural Research and Innovation System capable of supporting Africa's aspirations for food security, climate resilience, healthy soils, industrialization, and sustainable development. Strengthening the interactions among these institutional layers will therefore be more important than expanding any single organization in isolation.

4.7 Private-Sector Research and Development: The Emerging Driver of Agricultural Innovation

Globally, private-sector investment in agricultural research has driven significant advances in plant breeding, biotechnology, mechanization, digital agriculture, agrochemicals, food processing, and precision farming (Pardey et al., 2016). Such investments have accelerated innovation, enhanced value chains, and increased research responsiveness to evolving market demands.

In Africa, private-sector investment remains comparatively limited. Agricultural research continues to be led by National Agricultural Research Systems (NARS), universities, and CGIAR centres, whereas private-sector engagement is primarily focused on seed production, fertilizers, mechanization, veterinary products, food processing, and emerging digital agriculture enterprises.

The rapid expansion of agribusinesses, AgTech start-ups, biotechnology firms, and digital service providers is beginning to transform the agricultural innovation landscape. Investments in climate-resilient seed systems, artificial intelligence, drones, remote sensing, digital advisory platforms, precision nutrient management, financial technologies, and market information systems are accelerating the dissemination and commercialization of technologies.

Despite these advancements, weak intellectual property protection, limited access to venture capital, fragmented markets, insufficient research infrastructure, and policy uncertainty continue to inhibit sustained private investment. Expanding public-private partnerships, increasing innovation financing, and supporting technology incubation are therefore essential. The private sector should complement, rather than replace, public research by accelerating commercialization, scaling technologies, fostering agribusiness growth, and generating employment opportunities.

4.8 Agricultural Innovation Ecosystems: From Institutional Silos to Collaborative Networks

A major shift in agricultural development has been the transition from institution-centered research to **Agricultural Innovation Systems (AIS)**. Traditional models conceptualized innovation as a linear process, with researchers generating technologies that were subsequently transferred to farmers via extension services. In contrast, the AIS approach recognizes innovation as a collaborative process involving multiple stakeholders who jointly generate, adapt, disseminate, and apply knowledge.

Agricultural Innovation Systems integrate research institutes, universities, government agencies, extension services, private enterprises, financial institutions, development partners, civil society organizations, digital service providers, farmer organizations, and consumers. Within this ecosystem, NARS generate technologies, universities build human capital, CGIAR centers advance frontier science, SROs facilitate regional collaboration, FARA coordinates at the continental level, governments establish enabling policies, private enterprises commercialize innovations, financial institutions mobilize investment, extension services promote dissemination, and farmers validate and adapt new technologies.

Digital transformation has further enhanced these interactions. Artificial intelligence, remote sensing, geospatial technologies, digital soil information systems, climate information services, big data analytics, and mobile advisory platforms now connect institutions that previously operated independently, enabling more rapid knowledge exchange and evidence-based decision-making.

The AIS framework shifts performance assessment from measuring individual institutional outputs to evaluating collaboration, knowledge exchange, technology adoption, commercialization, and societal impact. Countries with robust innovation ecosystems are better positioned to accelerate agricultural transformation, attract private investment, address emerging challenges, and achieve sustainable food system outcomes.

Box 4.8. From Research Outputs to Market Impact: Building Effective Technology Transfer Systems in Africa

Africa's transition from a research-driven agricultural system to an Agricultural Innovation System (AIS) requires more than generating scientific knowledge and improved technologies. It demands institutional mechanisms that transform research outputs into commercially viable products, services, and enterprises capable of creating economic, social, and environmental value. Historically, many public agricultural research institutions have focused primarily on technology development, scientific publication, and intellectual property protection. While these remain important functions, limited attention has been given to technology commercialization, resulting in numerous innovations remaining within institutional repositories, research stations, or experimental fields without reaching farmers, agribusinesses, investors, or consumers at scale.

Transitioning publicly funded agricultural research into largescale commercial markets requires clear country-level execution pathways. Rather than allowing technologies to remain confined within institutional repositories, National Agricultural Research Systems (NARS) should establish dedicated Technology Transfer Offices (TTOs), business incubation programmes, spin-off company frameworks, intellectual property management systems, and transparent licensing models that facilitate partnerships with the private sector. These institutional mechanisms should actively support innovation packaging, market validation, investment readiness, regulatory compliance, and enterprise development.

At the regional level, Sub-Regional Organizations (SROs) and continental institutions such as FARA can strengthen commercialization by coordinating regional technology marketplaces that catalogue validated agricultural technologies, facilitate technology licensing, connect innovators with investors and agribusinesses, and enable successful innovations developed in one country to be rapidly adapted, commercialized, and scaled across national borders. Such platforms can also promote regional intellectual property management, harmonize licensing arrangements, and accelerate the diffusion of climate-smart and market-responsive innovations.

An effective Agricultural Innovation System therefore extends beyond research generation to encompass technology transfer, business development, investment facilitation, regulatory support, and market integration. Embedding commercialization as a core mandate of public agricultural research institutions will increase the return on public investment in research, stimulate private sector participation, create employment opportunities, and accelerate the delivery of research derived solutions that improve productivity, strengthen food systems, and drive Africa's agricultural transformation.

Table 4.5. Institutional Roles within Africa's Agricultural Innovation Ecosystem

Institution	Primary Function	Comparative Advantage	Major Contribution
National Agricultural Research Systems	Technology generation	National adaptive research	Scientific evidence and innovation
Universities	Human capital development	Education and multidisciplinary research	Scientific workforce and knowledge generation
CGIAR Centres	Strategic international research	Frontier science and global partnerships	Advanced technologies and capacity development
SROs	Regional coordination	Regional public goods	Cross-border collaboration and technology exchange
FARA	Continental coordination	Policy alignment and knowledge management	Strategic leadership and continental advocacy
Ministries of Agriculture and Science	Policy and regulation	National governance	Policy implementation and investment coordination
Private Sector	Commercialization	Market responsiveness	Technology scaling and agribusiness development
Extension Services	Knowledge dissemination	Farmer engagement	Technology adoption and feedback
Farmer Organizations	Innovation validation	Local knowledge	Participatory research and scaling

4.9 Conclusion

Africa maintains one of the most comprehensive agricultural research architectures globally, consisting of interconnected institutions at national, regional, continental, and international levels. National Agricultural Research Systems serve as the primary source of scientific knowledge, while universities focus on human capital development and research advancement. CGIAR centers contribute advanced scientific research and foster global partnerships. Sub-Regional Organizations facilitate regional collaboration, and FARA ensures continental coordination, policy alignment, knowledge management, and institutional leadership. Collectively, these entities constitute an integrated Agricultural Research and Innovation System that supports Africa's objectives for food security, climate resilience, soil health, economic transformation, and sustainable development.

The effectiveness of this architecture depends primarily on the strength of collaboration among institutions rather than the performance of individual entities. Agricultural innovation is increasingly generated through networks that feature multidirectional knowledge exchange, co-development of technologies, public-private partnerships, digital connectivity, and ongoing learning. This shift necessitates institutional reforms that prioritize coordination, interoperability, shared infrastructure, and strategic partnerships over organizational expansion.

Future efforts to strengthen Africa's agricultural research architecture will require sustained domestic investment, advanced scientific infrastructure, digitally enabled research systems, and enhanced science-policy interfaces. It is also essential to cultivate innovation ecosystems that integrate governments, universities, research institutes, private enterprises, financial institutions, development partners, and farming communities. These ecosystems will improve the continent's ability to address emerging challenges such as climate change, food system transformation, digital agriculture, biodiversity conservation, and increasing demand for nutritious and sustainable food.

This chapter posits that Africa's comparative advantage is derived not from the quantity of research institutions, but from the effectiveness of their collaboration in generating, adapting, disseminating, and applying knowledge for development. The institutional architecture outlined herein serves as the organizational foundation essential for Africa's agricultural transformation.

CHAPTER

5

Financing Agricultural Research in Africa: From Donor Dependence to Sustainable Investment

Summary The chapter examines the financing architecture of agricultural research in Africa, analyzing public investment, donor support, competitive grants, philanthropy, and privatesector financing. It argues that although agricultural research consistently generates among the highest economic returns of any public investment, it remains chronically underfunded because of political, institutional, and market failures. The chapter introduces the concept of the**Agricultural Research Investment Paradox (ARIP)** to explain the persistent mismatch between research returns and investment levels. It concludes by proposing diversified and sustainable financing pathways including national endowment funds, public-private partnerships, innovative financing mechanisms, and increased domestic investment to strengthen Africa's agricultural research and innovation system.

5.1 Introduction

Financing forms the foundation of agricultural research and innovation. Scientific discovery, technology development, laboratory modernization, capacity building, field experimentation, and knowledge dissemination all rely on sustained investment. Unlike many public programs, agricultural research requires long-term, predictable financing, as the development of improved crop varieties, climate-smart technologies, soil fertility innovations, animal genetics, and digital solutions often takes a decade or more to yield measurable impact.

Extensive evidence demonstrates that agricultural research is among the highest-return public investments. Studies estimate annual returns ranging from **20% to over 60%**, with benefits extending beyond agricultural productivity to include improved food security, farm incomes, employment, environmental sustainability, climate resilience, and economic growth (Alston et al., 2000; Hurley et al., 2016; Pardey et al., 2016). Consequently, agricultural research should be regarded not only as a scientific endeavor but also as a strategic investment in national development.

Despite these demonstrated benefits, agricultural research in Africa remains chronically underfunded. Many National Agricultural Research Systems (NARS) operate with inadequate budgets, aging infrastructure, limited laboratory facilities, and shortages of qualified scientists. Universities encounter similar constraints, and heavy reliance on donor funding exposes research programs to shifting external priorities and funding uncertainty.

The challenge extends beyond insufficient funding. Agricultural research financing is fragmented among governments, development partners, international research organizations, philanthropic foundations, competitive grants, and a relatively small private sector. Although this diversity broadens funding opportunities, it frequently leads to fragmented research agendas, weak national ownership, duplication of efforts, and limited institutional sustainability.

This chapter contends that Africa's primary challenge is not merely insufficient investment, but rather the absence of a sustainable financing architecture capable of supporting long-term scientific excellence. The **Agricultural Research Investment Paradox (ARIP) is introduced** to explain why

agricultural research remains one of Africa's highest-return yet least-funded public investments. The chapter proposes financing pathways that are predictable, diversified, nationally owned, and aligned with continental priorities, including the Kampala Declaration, STISA-2034, Agenda 2063, the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP).

5.2 The Agricultural Research Investment Paradox (ARIP): An Emerging Concept

A significant contradiction in African agricultural development is the disparity between the demonstrated value of agricultural research and the limited investment it receives. Decades of evidence indicate that research enhances crop and livestock productivity, soil fertility, climate resilience, digital innovation, and food system performance, while also contributing to poverty reduction, industrialization, environmental sustainability, and economic growth.

Nevertheless, agricultural research remains one of the least financed components of national agricultural budgets. Governments frequently prioritize recurrent expenditures, input subsidies, emergency food imports, and highly visible infrastructure projects over long-term scientific investment. Since the benefits of research generally materialize beyond political and electoral cycles, it receives less attention despite its superior long-term returns.

This chapter defines this disconnect as the **Agricultural Research Investment Paradox (ARIP), which refers to the** persistent underinvestment in agricultural research despite overwhelming evidence that it is among the most productive public investments for sustainable agricultural and economic transformation.

Definition

The Agricultural Research Investment Paradox (ARIP) refers to the persistent mismatch between the exceptionally high economic and social returns generated by agricultural research and the relatively low levels of public and private investment allocated to agricultural research systems.

Several reinforcing factors drive the Agricultural Research Investment Paradox (ARIP). First, agricultural research exhibits many characteristics of public goods. Its benefits are diffuse, long-term, and difficult for individual investors to appropriate, which reduces incentives for private-sector investment. Second, the lengthy period required for research to yield measurable outcomes discourages political investment, particularly within short electoral cycles. Third, the benefits of agricultural research are often indirect and insufficiently communicated, rendering them less visible than investments in physical infrastructure such as roads, irrigation systems, or distribution programs. Finally, inadequate monitoring and impact assessment systems frequently fail to capture the full economic contribution of agricultural research, diminishing its influence in national budget allocation processes.

A comprehensive understanding of the Agricultural Research Investment Paradox offers a critical conceptual foundation for developing sustainable financing strategies. Addressing the investment gap necessitates reframing agricultural research as a strategic investment in national productivity, resilience, food security, and economic competitiveness, rather than as a recurrent expenditure.

Figure 5.1. The Agricultural Research Investment Paradox (ARIP)

Figure 5.1 illustrates the central argument of this chapter. Although agricultural research consistently produces exceptionally high economic and societal returns, these benefits are not reflected in the level of investment allocated to research institutions. The gap between expected and actual investment constitutes the Agricultural Research Investment Paradox.

5.3 Public Financing as the Foundation of National Agricultural Research Systems

Public financing remains the cornerstone of agricultural research across Africa. Governments provide funding for the establishment and operation of National Agricultural Research Systems (NARS), agricultural universities, public laboratories, experimental stations, gene banks, extension-support research, and regulatory institutions. Public investment is especially critical because many agricultural research outputs, including improved crop varieties, soil health recommendations, disease surveillance systems, climate information services, and policy research, constitute public goods. The benefits of these outputs extend across society and cannot be easily captured through market mechanisms.

Historically, public investment has enabled African countries to establish national research institutes responsible for developing technologies tailored to local agroecological conditions. These institutions have generated improved crop varieties, livestock breeds, integrated pest management strategies, natural resource management practices, and policy innovations that have significantly advanced agricultural development. Public funding has also facilitated postgraduate training, national germplasm conservation, food safety research, and strategic research addressing emerging challenges such as climate change and soil degradation.

However, the level and predictability of public financing vary significantly across the continent. While some countries maintain relatively stable investment in agricultural research, many allocate only limited resources to research institutions, despite the substantial contribution of agriculture to national economies. Budget allocations are often dominated by salaries and administrative costs,

leaving insufficient funding for field experimentation, laboratory operations, equipment maintenance, scientific publications, and technology dissemination. Consequently, many research institutions depend heavily on externally funded projects to sustain core scientific activities.

The long-term sustainability of Africa's agricultural research system fundamentally depends on strengthening domestic public investment. Governments should view agricultural research as a strategic national investment that supports food security, climate resilience, industrialization, and economic competitiveness, rather than as a discretionary expenditure subject to reduction during fiscal constraints.

Table 5.1. Public Financing Mechanisms for Agricultural Research

Public Financing Mechanism	Principal Source	Strengths	Major Limitations
National Treasury Allocations	Central government budgets	Stable institutional support and national ownership	Often insufficient and vulnerable to fiscal pressures
Ministries of Agriculture	Sectoral budgets	Strong alignment with national agricultural priorities	Annual budget uncertainty and competing sectoral demands
Ministries of Science and Technology	National science budgets	Supports strategic and frontier research	Limited focus on agriculture in many countries
National Research Councils	Competitive public grants	Promotes scientific excellence and accountability	Small funding envelopes and uneven accessibility
Public Universities	Government subventions	Supports teaching, research, and human capital development	Research is often underfunded relative to teaching mandates

Public financing provides the institutional backbone of agricultural research. However, its effectiveness depends not only on the amount invested but also on the predictability, efficiency, and strategic alignment of resource allocation with national and continental development priorities.

5.4 Donor Financing: Advancing Agricultural Research and Addressing Dependency Risks

External development assistance has played a pivotal role in shaping the agricultural research landscape in Africa. Since the 1960s, bilateral and multilateral agencies, international financial institutions, and philanthropic organizations have made substantial investments to strengthen National Agricultural Research Systems (NARS), universities, CGIAR centres, regional organizations, and continental institutions. These investments have enhanced research infrastructure, postgraduate training, laboratory equipment, technology development, policy reform, institutional capacity, and regional collaboration (Beintema and Stads, 2017).

Key partners, including the World Bank, African Development Bank (AfDB), IFAD, FAO, the European Union, USAID, GIZ, JICA, FCDO, and philanthropic foundations such as the Bill and Melinda Gates Foundation, Mastercard Foundation, Rockefeller Foundation, and Wellcome Trust, have made significant contributions to initiatives such as CAADP, the Science Agenda for Agriculture in Africa (S3A), the Soil Initiative for Africa (SIA), the Africa Fertilizer and Soil Health Action Plan (AFSH-AP), the African Union Soil Observatory (AUSO), and various CGIAR Programs.

Despite these achievements, substantial reliance on donor funding has introduced structural challenges. Project-based financing frequently aligns research agendas with donor priorities instead of national needs. Additionally, short funding cycles undermine institutional continuity, fragment research agendas, and increase administrative burdens. Donor financing should therefore act as a catalyst for domestic investment rather than replace it. Sustainable research systems depend on predictable national financing, complemented by strategically targeted external support.

5.5 Competitive Research Grants: Fostering Scientific Excellence and Innovation

Competitive grants have emerged as a significant source of agricultural research financing by allocating resources based on scientific merit, innovation, collaboration, and anticipated impact. African researchers are increasingly securing funding through FARA, the African Academy of Sciences (AAS), RUFORUM, the African Union Commission, CGIAR, Horizon Europe, the African Development Bank, the World Bank, and bilateral development agencies. These Programs support research in areas such as climate-smart agriculture, biotechnology, soil health, digital agriculture, mechanization, food systems, and youth employment.

Competitive grants enhance research quality by rewarding excellence, fostering multidisciplinary partnerships, strengthening accountability, and exposing African scientists to international standards. However, these grants also present challenges. Institutions with greater proposal-writing capacity often secure a disproportionate share of funding, while many grants prioritize short-term project outputs over long-term institutional development. Furthermore, administrative requirements may disadvantage smaller organizations.

Competitive grants should therefore serve to complement, rather than replace, stable institutional funding. Although these grants stimulate innovation and scientific excellence, sustained public investment is essential for maintaining research infrastructure, laboratories, experimental facilities, and scientific personnel.5.6 Philanthropy: An Emerging Contributor to Agricultural Research Financing

Philanthropic organizations have become increasingly significant contributors to agricultural research in Africa by supporting innovation, climate resilience, digital agriculture, nutrition, entrepreneurship, and food systems transformation. Foundations such as the Bill and Melinda Gates Foundation, Rockefeller Foundation, Mastercard Foundation, and Wellcome Trust have invested in crop improvement, livestock development, soil health, digital advisory systems, youth employment, leadership development, and interdisciplinary research.

Philanthropic funding provides several advantages, including greater flexibility, a willingness to support high-risk innovations, and long-term investment in leadership and institutional development. However, the scale of philanthropic funding remains modest relative to Africa's research needs, and funding priorities inevitably reflect the strategic interests of individual foundations.

An emerging opportunity exists in expanding African philanthropy. Corporate foundations, high-net-worth individuals, sovereign wealth funds, and corporate social responsibility Programs are increasingly investing in education, innovation, and sustainable development. Mobilizing these domestic philanthropic resources could diversify agricultural research financing, strengthen national ownership, and reduce dependence on external funding.

Table 5.2. Comparative Assessment of Major Agricultural Research Financing Mechanisms

Financing Source	Principal Strengths	Major Limitations	Long-term Sustainability
Public Financing	National ownership, institutional stability, alignment with national priorities	Often inadequate and vulnerable to fiscal constraints	**High** (if adequately funded)
Donor Financing	Large financial resources, capacity development, infrastructure, regional collaboration	Project dependency, shifting priorities, limited continuity	**Moderate**
Competitive Grants	Promotes scientific excellence, innovation and accountability	Short-term funding, unequal access, high transaction costs	**Moderate**
Philanthropic Investment	Flexible financing, innovation, leadership development	Limited scale, foundation-specific priorities	**Moderate**
Private-sector Investment	Commercialization, market responsiveness, technology scaling	Limited investment in public-good research	**High** (with enabling policies)

Table 5.2 illustrates that no single financing mechanism can adequately sustain Africa's agricultural research system. Rather, long-term sustainability requires a diversified financing portfolio that combines predictable public investment with strategically targeted external resources and increasing private-sector participation.

5.7 Private-Sector Investment: Catalyzing Market-Driven Agricultural Innovation

Globally, the private sector serves as a principal investor in agricultural research and development (R&D), particularly in crop breeding, biotechnology, mechanization, digital agriculture, food processing, agrochemicals, and precision farming. In many developed economies, private firms contribute more than half of agricultural R&D expenditure, facilitated by robust intellectual property systems and established innovation ecosystems (Pardey et al., 2016).

In Africa, private investment remains comparatively limited, with the majority of agricultural research funded by governments and development partners. Current private-sector investments are primarily focused on hybrid seeds, fertilizers, veterinary pharmaceuticals, mechanization, irrigation technologies, food processing, and emerging AgTech enterprises. However, the rapid expansion of digital agriculture, biotechnology, climate-smart agriculture, and financial technology is creating new opportunities for private-sector engagement.

Private investment accelerates the commercialization of technology, increases responsiveness to market demand, and fosters innovation through efficient product development, manufacturing, and dissemination. Effective public-private partnerships have reinforced seed systems, mechanization, biological inputs, precision agriculture, and digital advisory services in multiple African countries.

However, increased investment is hindered by insufficient intellectual property protection, fragmented markets, restricted access to long-term finance, policy uncertainty, and inadequate research infrastructure. Furthermore, numerous research domains including soil health, biodiversity conservation, natural resource management, and policy research produce public benefits that are not readily commercialize. Therefore, strengthening **public-private partnerships (PPPs) is essential**, with governments supporting strategic public-good research and private enterprises leading product development, commercialization, manufacturing, and market expansion.

5.8 Persistent Weaknesses in Agricultural Research Funding

The ongoing underfunding of agricultural research is attributable to more than fiscal constraints. Political, institutional, and structural factors diminish the visibility and priority of research in national investment decisions, thereby reinforcing the Agricultural Research Investment Paradox (ARIP).

A significant constraint is political short-termism. Agricultural research typically requires five to fifteen years to yield measurable impacts, while political leaders generally operate within four- or five-year electoral cycles. Consequently, governments often prioritize highly visible investments, such as roads, irrigation, subsidies, and food imports, over long-term scientific research.

The public-good characteristics of agricultural research further restrict private investment. Numerous outputs—including improved germplasm, soil fertility recommendations, pest surveillance systems, climate information, and policy analysis—provide broad societal benefits that private firms cannot fully appropriate, thereby assigning primary responsibility for financing to governments.

Agricultural research also experiences low political visibility. In contrast to physical infrastructure, scientific discoveries and capacity development yield few immediate or tangible outputs, rendering them less appealing during budget negotiations. Inadequate monitoring and impact assessment further constrain research institutions' ability to demonstrate their economic contributions.

Additional challenges encompass fragmented financing across multiple agencies and donors, limited commercialization of research outputs, weak technology transfer systems, inadequate intellectual property management, and insufficient venture capital. Furthermore, agricultural research has lacked robust political advocacy, with scientific evidence frequently failing to reach finance ministries and national planning authorities in a persuasive economic format.

Collectively, these factors account for the persistent underinvestment in agricultural research, despite its consistently high social and economic returns relative to other public expenditures. Addressing the ARIP will necessitate stronger political commitment, coordinated financing, effective commercialization, and sustained advocacy for agricultural research as a strategic national investment.

Table 5.3. Drivers of Chronic Underinvestment in Agricultural Research

Driver	Effect on Agricultural Research Financing	Policy Implication
Political short-termism	Preference for projects with immediate visible benefits	Establish long-term research financing commitments beyond electoral cycles
Public-good characteristics	Limited incentives for private investment	Sustain strong public financing for strategic research
Weak research advocacy	Low political visibility during budget allocation	Strengthen science-policy communication and evidence-based advocacy
Donor dependence	Reduced national ownership and fragmented priorities	Increase domestic financing and align external support with national strategies
Fragmented financing architecture	Duplication, inefficiency, and high transaction costs	Coordinate financing through national research investment frameworks
Weak commercialization	Limited revenue generation by research institutions	Strengthen technology transfer, intellectual property, and innovation ecosystems
Weak monitoring and impact assessment	Underestimation of research returns	Improve impact evaluation and communicate the economic benefits of research

Table 5.3 demonstrates that chronic underinvestment is not merely a consequence of limited financial resources but reflects deeper institutional and political economy challenges that require systemic reforms.

5.9 Political Underinvestment: A Structural Challenge

The allocation of funding for agricultural research is determined by prevailing political priorities. While governments acknowledge the significance of science and innovation, public resources are constrained and distributed among competing sectors, including health, education, infrastructure, security, and social protection. As a result, agricultural research frequently receives less priority than programs that deliver immediate and visible political returns.

This pattern of underinvestment is paradoxical, given that agriculture is one of Africa's largest sources of employment and a significant driver of economic growth. Despite this, only a small proportion of agricultural budgets is allocated to research, with greater shares directed toward subsidies, recurrent expenditures, food imports, and infrastructure. While these allocations are important, insufficient research funding constrains the development of technologies necessary to enhance long-term productivity and resilience.

Political short-termism perpetuates this trend. Scientific advancements typically require extended periods to yield measurable outcomes, rendering research less appealing within the constraints of electoral cycles. As a result, agricultural research is often regarded as discretionary spending rather than as essential national infrastructure.

Addressing this challenge necessitates reframing agricultural research as a strategic investment in economic growth, food security, industrialization, climate resilience, and reduced reliance on food imports. The experiences of Brazil, China, India, and the Republic of Korea illustrate that sustained political commitment to agricultural research can transform national food systems and enhance competitiveness. Realizing Africa's objectives under Agenda 2063, the Kampala Declaration, STISA-2034, and the Sustainable Development Goals will require comparable long-term investments.

5.10 Sustainable Financing Pathways for Agricultural Research

African agricultural research systems require financing that is predictable, diversified, nationally owned, and resilient. Global experience demonstrates that effective research systems rely on multiple complementary funding sources rather than a single financing mechanism.

A robust foundation of domestic public investment is essential, as many research outputs—such as improved germplasm, soil health technologies, climate information services, biodiversity conservation, and policy research constitute public goods. Consistent government funding is critical for supporting laboratories, research farms, scientific personnel, and long-term experiments, while also reinforcing national ownership of research agendas.

In addition to public funding, African countries should diversify financing through Agricultural Research Endowment Funds, supported by governments, development partners, commodity organizations, sovereign wealth funds, private enterprises, philanthropic foundations, and high-net-worth individuals. These endowments can offer sustainable financing for strategic research, infrastructure, postgraduate training, and emerging scientific priorities.

Additional financing opportunities include commodity levies on agricultural value chains, climate finance, biodiversity and carbon markets, ecosystem restoration funds, and other green financial instruments that support climate-smart agriculture and sustainable land management. Governments should also enhance public-private partnerships to facilitate collaborative research, technology incubation, commercialization, and investment in innovation.

At the continental level, Africa should consider creating a Pan-African Agricultural Research and Innovation Fund to finance regional public goods, advanced research infrastructure, digital platforms, postgraduate mobility, strategic foresight, and transboundary research. This mechanism would complement national investments and accelerate the implementation of Agenda 2063, the Kampala Declaration, STISA-2034, and related continental initiatives.

In conclusion, sustainable financing should integrate public investment for institutional stability, donor support for catalytic innovation, competitive grants for scientific excellence, philanthropy for experimentation, private-sector investment for commercialization, and innovative mechanisms for long-term resilience. Collectively, these financing streams form the basis for a robust and self-sustaining African agricultural research system.

Table 5.4. Proposed Sustainable Financing Pathways for Agricultural Research

Financing Mechanism	Potential Source	Strategic Advantage	Expected Impact
Increased Public Investment	National budgets	Long-term institutional stability	Sustainable core research programs.
Agricultural Research Endowment Fund	Governments, donors, foundations, sovereign wealth funds	Predictable long-term financing	Stable support for strategic research
Commodity Levies	Agricultural value chains	Industry ownership	Financing commodity-specific research
Public-Private Partnerships	Agribusinesses and technology companies	Commercialization and technology scaling	Faster innovation uptake
Climate and Carbon Finance	Global climate funds	Supports adaptation and mitigation research	Climate-resilient agricultural systems
Competitive Grant Schemes	National and international science funds	Scientific excellence	High-quality research outputs
Philanthropic Investment	Foundations and corporate philanthropy	Innovation and leadership development	Emerging research priorities
Regional Research Fund	African Union, RECs, development partners	Regional public goods	Cross-border collaboration and shared infrastructure

Table 5.4 illustrates that no single financing mechanism can sustain Africa's agricultural research system. A diversified financing portfolio is essential for long-term resilience, national ownership, and innovation.

5.11 Conclusion

Agricultural research is among the most effective public investments for enhancing productivity, food security, climate resilience, poverty reduction, and economic transformation. Despite substantial evidence of its economic and social benefits, research financing in much of Africa remains insufficient, fragmented, and highly reliant on external assistance. This chapter contends that the primary challenge extends beyond the volume of funding to include its predictability, sustainability, national ownership, and strategic alignment.

This chapter introduced the Agricultural Research Investment Paradox (ARIP) to elucidate the ongoing disparity between the substantial returns generated by agricultural research and the comparatively low levels of investment it attracts. Factors such as political short-termism, the public-good nature of research, fragmented financing, limited commercialization, insufficient advocacy, and continued donor dependence constrain the long-term development of National Agricultural Research Systems.

Resolving this paradox requires establishing a new financing architecture grounded in increased domestic investment, supplemented by competitive grants, philanthropic contributions, private-sector engagement, climate finance, commodity levies, research endowment funds, and robust public-private partnerships. A diversified financing portfolio will enhance stability, support sustained scientific excellence and mitigate vulnerability to fluctuations in external funding.

The successful implementation of Agenda 2063, the Kampala Declaration, STISA-2034, the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) will depend on robust and sustainable research financing. Ultimately, no agricultural research system can outperform the strength of its financing architecture. Investing in agricultural research is therefore not merely a budgetary commitment; it is a strategic investment in Africa's capacity to generate knowledge, drive innovation, strengthen competitiveness, and achieve sustainable agricultural transformation.

Box 5.1. The Case for an African Agricultural Research Endowment Fund

The future of Africa's agricultural transformation depends not only on the quality of its scientists or the strength of its institutions but also on the sustainability of its financing systems. While external development assistance has played a pivotal role in building Africa's agricultural research capacity over the past five decades, donor-funded projects alone cannot provide the stable, long-term investment required for scientific excellence. Agricultural research is inherently a long-term enterprise. Developing improved crop varieties, restoring degraded soils, strengthening livestock systems, adapting agriculture to climate change, and building scientific capacity often require sustained investment over many years. Project-based financing, typically limited to three to five years, rarely matches these scientific timelines. Consequently, promising research programmes frequently lose momentum when external funding ends, resulting in discontinuity, loss of expertise, and underutilization of research infrastructure.

The establishment of an **African Agricultural Research Endowment Fund (AAREF)** would represent a strategic shift from financing projects to financing institutions and long-term scientific capability. Unlike conventional donor projects, an endowment fund preserves its capital while investing it to generate annual income that can be used to finance research. This approach creates predictable, sustainable, and independent funding that is insulated from annual budget fluctuations and changing donor priorities.

The proposed endowment should function as a continental financing mechanism jointly owned by African governments and supported by strategic partners. Capitalization could come from multiple sources, including annual contributions from African Union Member States, allocations from the African Development Bank, contributions from AUDA-NEPAD, Regional Economic Communities, sovereign wealth funds, commodity boards, agribusiness corporations, philanthropic foundations, development finance institutions, climate finance facilities, and voluntary contributions from Africa's private sector and diaspora. Such diversification would reduce reliance on any single funding source while strengthening continental ownership of agricultural research.

Investment income generated by the fund could support strategic priorities that are often inadequately financed through conventional projects. These include long-term research programmes, modernization of laboratories and research farms, postgraduate scholarships, scientific mobility, digital research infrastructure, emerging technologies such as artificial intelligence and biotechnology, regional centres of excellence, innovation commercialization, and rapid-response research addressing emerging threats such as transboundary pests, pandemics, and climate-related disasters.

The governance of the endowment would be critical to its credibility and effectiveness. An independent Board of Trustees representing governments, research institutions, universities, private-sector organizations, development partners, and civil society should oversee the fund under transparent financial and investment rules. Funding decisions should be based on scientific excellence, strategic relevance, and measurable development impact, supported by rigorous monitoring, evaluation, and periodic independent audits.

Beyond financing, an African Agricultural Research Endowment Fund would carry profound symbolic significance. It would signal a transition from a model of externally driven research to one founded on African ownership, African priorities, and African accountability. Such a fund would reinforce the implementation of Agenda 2063, the Kampala Declaration, STISA-2034, the Soil Initiative for Africa, and the Africa Fertilizer and Soil Health Action Plan by providing the long-term financial foundation required for sustained scientific innovation.

Ultimately, Africa's capacity to feed its growing population, restore its natural resources, compete in global agricultural markets, and build resilient food systems will depend on sustained investment in knowledge generation. Establishing an African Agricultural Research Endowment Fund would therefore represent far more than a financing mechanism; it would be a strategic investment in the continent's scientific sovereignty, economic competitiveness, and long-term development. As Africa continues to champion **African-owned and African-led development**, the next decisive step is to ensure that agricultural research becomes **African-funded**. That transition will determine whether the continent's scientific ambitions are constrained by funding cycles or sustained by a permanent commitment to innovation and transformation.

CHAPTER 6

Research Capacity, Infrastructure and Human Capital for Agricultural Transformation in Africa

Summary

This chapter examines the human, institutional, and technological capacities underpinning Africa's agricultural research and innovation system. It introduces the **Agricultural Research Capacity Gap (ARCG)** to describe the disparity between the capacities required to achieve Africa's agricultural transformation agenda and those currently available. The chapter reviews the continent's scientific workforce, research infrastructure, digital capabilities, and emerging skills requirements while highlighting persistent constraints such as brain drain, ageing researchers, inadequate laboratories, and weak digital capacity. It concludes that sustainedinvestment in people, infrastructure, and innovation ecosystems is essential for building resilient National Agricultural Research Systems capable of delivering Africa's long-term agricultural development aspirations.

6.1 Introduction

Agricultural research is fundamentally a knowledge enterprise driven by people, infrastructure, and institutions. Regardless of the availability of financial resources or policy commitments, the effectiveness of a research system ultimately depends on the quality of its scientific workforce, research facilities, technological capabilities, and institutional capacity. Scientific discoveries, technology development, policy analysis, and innovation all originate from well-trained researchers operating within enabling research environments. Consequently, research capacity constitutes one of the most strategic assets for agricultural transformation.

Africa's ambition to achieve food security, climate resilience, competitive agrifood systems, and sustainable natural resource management, as articulated in the CAADP Kampala Declaration, Agenda 2063, STISA-2034, the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP), requires research systems capable of generating world-class science while responding effectively to local development challenges. However, many National Agricultural Research Systems (NARS) continue to face shortages of qualified scientists, aging infrastructure, inadequate laboratory facilities, weak digital capabilities, and limited investment in emerging technologies. These constraints reduce the continent's ability to generate innovations at the pace required to support agricultural transformation.

This chapter introduces the concept of the Agricultural Research Capacity Gap (ARCG) to describe the disparity between the research capacity required to achieve Africa's agricultural development aspirations and the capacity currently available within national and regional research institutions.

Agricultural Research Capacity Gap (ARCG): ***The difference between the scientific, technological, human, and institutional capacities required to achieve Africa's agricultural transformation agenda and the capacities currently available within National Agricultural Research Systems and their partner institutions.***

Understanding and narrowing this gap is central to strengthening Africa's scientific competitiveness and reducing dependence on imported technologies and knowledge.

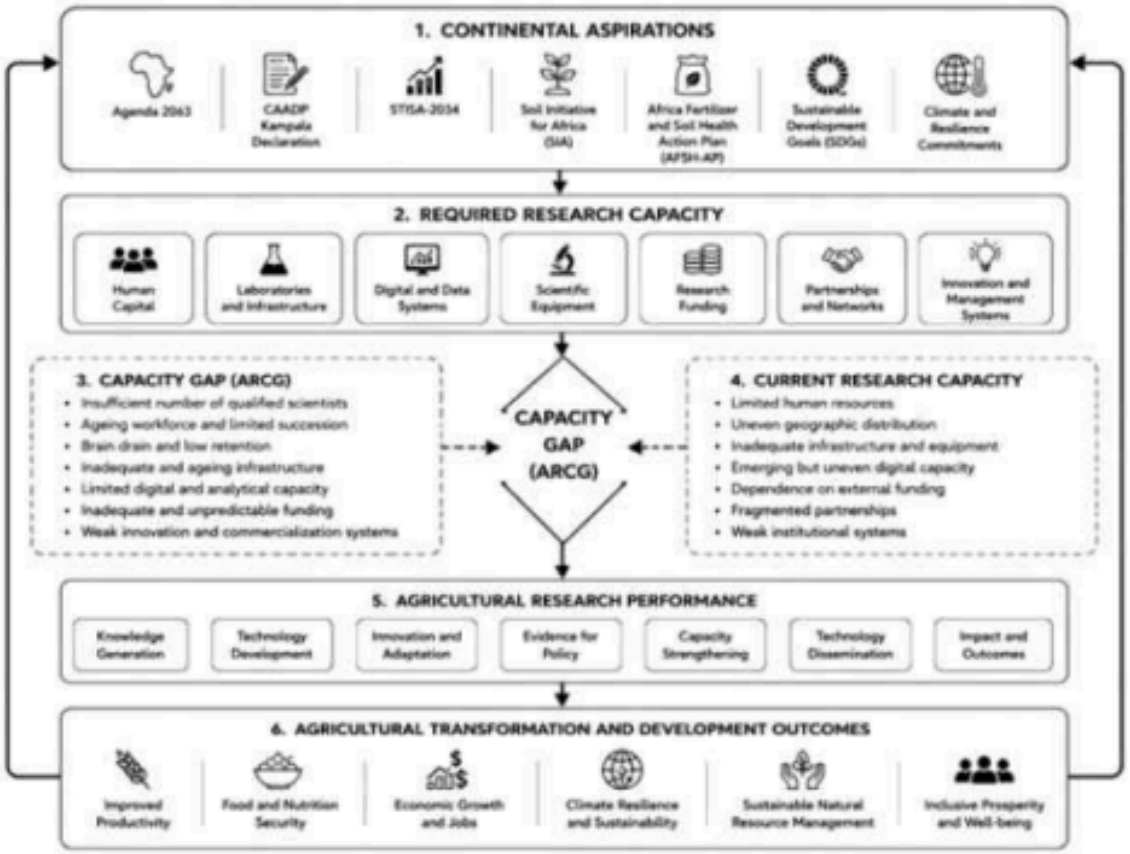


Figure 6.1. The Agricultural Research Capacity Gap (ARCG)

Figure 6.1 illustrates that the principal determinant of research performance is the gap between the capacity required to deliver continental aspirations and the scientific capacity currently available within African research institutions.

6.2 Human Capital: The Foundation of Agricultural Research

Human capital constitutes the most valuable asset within any agricultural research system. Laboratories, experimental farms, digital platforms, and sophisticated equipment achieve productivity only when supported by skilled scientists, technicians, research managers, and innovation leaders. Investments in human capital generate returns that extend beyond individual research projects by strengthening institutional memory, scientific leadership, technology development, and national innovation capacity.

During the past three decades, Africa has achieved measurable progress in expanding its agricultural research workforce. The Agricultural Science and Technology Indicators (ASTI) reports that both the number of agricultural researchers and the proportion holding postgraduate qualifications have increased. However, this growth remains uneven. A small number of countries, including Nigeria, South Africa, Kenya, Ethiopia, Egypt, Morocco, and Ghana, account for a substantial share of Africa's agricultural scientists, while many smaller and low-income countries continue to operate with limited research personnel and constrained technical capacity (Beintema and Stads, 2017; IFPRI, 2024).

In addition to changes in the number of researchers, the composition of the workforce is evolving. Many public research organizations face an ageing scientific workforce as senior researchers

approach retirement, while recruitment of young scientists often lags due to fiscal constraints and limited career opportunities. This trend threatens institutional continuity and increases the risk of losing decades of accumulated scientific knowledge. Simultaneously, Africa's expanding university sector is producing more MSc and PhD graduates, which could rejuvenate research institutions if effective recruitment and mentorship programs are implemented.

The quality of agricultural research increasingly relies on multidisciplinary expertise. Contemporary scientists require proficiency in traditional agricultural disciplines as well as in artificial intelligence, data science, genomics, climate modeling, geospatial analysis, systems thinking, innovation management, and science-policy engagement. Therefore, future capacity development strategies should prioritize strengthening scientific diversity, digital competence, leadership, and interdisciplinary collaboration, rather than focusing solely on increasing researcher numbers.

Table 6.1. Status of Agricultural Research Human Capacity in Africa

Capacity Component	Current Status*	Major Challenge	Strategic Priority	Key References
Agricultural researchers	Increasing, but unevenly distributed across countries	Concentration of expertise in relatively few countries	Expand recruitment and equitable national capacity	Beintema and Stads (2017); IFPRI (2024)
PhD-qualified scientists	Growing through universities and regional Programs	Insufficient numbers in several NARS	Strengthen postgraduate education and scientific mentorship	RUFORUM (2024); FARA (2014)
Age profile of researchers	Large cohort approaching retirement in many public institutions	Potential loss of institutional memory	Succession planning and youth recruitment	ASTI/IFPRI (2024)
Women in agricultural research	Improving participation, but underrepresented in senior positions	Gender imbalance in leadership and STEM disciplines	Gender-responsive recruitment and career advancement	UNESCO (2021); ASTI
Research management capacity	Variable among countries	Limited professional research management and leadership skills	Institutional leadership development and governance reform	OECD (2015); FARA (2014)
Digital competencies	Emerging but uneven	Limited expertise in AI, data science and digital agriculture	Digital skills development and continuous professional training	STISA-2034; World Bank (2012)

Table 6.1 demonstrates that Africa has made encouraging progress in strengthening its scientific workforce, but significant disparities remain across countries and disciplines. Future investments should therefore prioritize both the expansion and modernization of human capital to meet the demands of contemporary agricultural research.

Box 6.1. Africa's Scientific Workforce: Progress and Persistent Gaps

Recent assessments by the Agricultural Science and Technology Indicators (ASTI)programme show that Africa's agricultural research workforce has expanded steadily over the past two decades, reflecting increased investment in postgraduate education and institutional development. However, this growth remains uneven, with a relatively small number of countries accounting for much of the continent's scientific capacity. Many National Agricultural Research Systems continue to experience ageing workforces, shortages of specialized technical staff, limited opportunities for young scientists, and constrained operational resources. These disparities highlight the importance of sustained investment in recruitment, mentorship, and professional development to ensure that research capacity keeps pace with Africa's growing agricultural ambitions (Beintema & Stads, 2017; IFPRI, 2024).

6.3 Research Infrastructure: The Physical Foundation of Scientific Excellence

High-quality agricultural research relies on access to advanced scientific infrastructure. Although human capital is essential for scientific discovery, research infrastructure establishes the physical context necessary for generating, validating, and translating knowledge into innovation. Laboratories, experimental farms, research stations, gene banks, greenhouses, soil and plant analytical laboratories, livestock research facilities, weather stations, digital data platforms, and high-performance computing systems together form the foundation of modern agricultural research.

During the past three decades, numerous African countries have made significant investments in agricultural research infrastructure through government funding and assistance from development partners. Several countries have established new biotechnology laboratories, molecular breeding facilities, soil testing laboratories, climate observation networks, and innovation centres. Continental initiatives, including the African Union Soil Observatory (AUSO), the Soil Initiative for Africa (SIA), the Comprehensive Africa Agriculture Development Program (CAADP), and regional Centres of Excellence, have further enhanced scientific infrastructure and fostered increased collaboration among research institutions.

Despite these advancements, substantial infrastructure gaps remain. Many National Agricultural Research Systems still operate outdated laboratories with obsolete analytical instruments, poorly maintained research farms, inadequate irrigation systems, limited greenhouse facilities, unreliable electricity supply, and insufficient laboratory consumables. Advanced facilities for genomics, bioinformatics, precision agriculture, remote sensing, robotics, and artificial intelligence are concentrated in a small number of countries, restricting equitable access to cutting-edge scientific technologies.

Research infrastructure should be regarded not only as physical assets but also as strategic national investments. Modern facilities enhance scientific productivity, improve research quality, attract highly qualified researchers, strengthen postgraduate education, facilitate international collaboration, and accelerate technology commercialization. Continued investment in infrastructure modernization is essential for Africa to compete effectively in the global knowledge economy.

Table 6.2. Major Agricultural Research Infrastructure Gaps in Africa

Infrastructure Component	Current Status	Strategic Priority	Key References
Soil analytical laboratories	Uneven distribution; limited modern analytical capacity in many countries	Upgrade analytical equipment and quality assurance systems	FAO (2022); ISRIC (2023)
Biotechnology and molecular laboratories	Advanced facilities concentrated in relatively few countries	Expand regional centres and shared facilities	STISA-2034; CGIAR (2023)
Research farms and experimental stations	Ageing infrastructure with inadequate modernization	Rehabilitate field station s and strengthen mechanization	ASTI/IFPRI (2024)
Weather and climate observation systems	Variable spatial coverage and data quality	Expand automated climate monitoring networks	WMO (2023)
Digital research infrastructure	Rapidly improving but uneven inter net connectivity and computing capacity	Invest in cloud computing, open science platforms and digital repositories	World Bank (2023)
Innovation and technology incubation facilities	Limited availability within many NARS and universities	Strengthen commerci alization and incubation ecosystems	FARA (2014); OECD (2015)

Evidence Box 6.2. Infrastructure Quality Determines Research Competitiveness
Evidence from the Agricultural Science and Technology Indicators (ASTI) programmeand continental infrastructure assessments demonstrates that countries possessing modern laboratories, well maintained research farms, advanced analytical equipment, and reliable digital infrastructure consistently achieve higher scientific productivity, stronger postgraduate training programmes, and greater international research collaboration. Conversely, ageing infrastructure, inadequate maintenance, and limited access to advanced scientific equipmentcontinue to constrain research quality and innovation across many National Agricultural Research Systems. Investment in infrastructure modernization should therefore be regarded as an investment in scientific competitiveness rather than simply in physicalfacilities (ASTI/IFPRI, 2024; FAO, 2022).

6.4 Digital Transformation and the Redefinition of Agricultural Research Capacity

The Fourth Industrial Revolution is fundamentally transforming agricultural research. Advances in artificial intelligence (AI), machine learning, remote sensing, geographic information systems (GIS), unmanned aerial vehicles (UAVs), genomics, bioinformatics, cloud computing, big data analytics, Internet of Things (IoT) technologies, and digital decision-support systems are reshaping the processes by which agricultural knowledge is generated, analyzed, and disseminated. The competitiveness of research institutions now depends not only on physical infrastructure but also on robust digital capabilities.

Significant progress has been made across Africa in adopting digital technologies for agricultural research. Multiple countries have established digital soil information systems, national agricultural data platforms, precision agriculture programs, and climate information services. Initiatives such as the digital agricultural innovation hubs and open-access scientific repositories reflect a growing continental commitment to digital transformation. Furthermore, mobile technologies, satellite imagery, and cloud-based data management systems are enhancing research efficiency and supporting evidence-based policy development.

Despite these advancements, the adoption of digital transformation remains inconsistent. Numerous research institutions face challenges such as inadequate internet connectivity, limited computing infrastructure, fragmented databases, weak data governance, shortages of data scientists, and insufficient digital skills among researchers. Additionally, issues related to cybersecurity, interoperability, data ownership, and long-term digital preservation require greater attention as research activities become increasingly data intensive.

Digital transformation should be regarded as a fundamental component of research capacity rather than a supplementary investment. Future agricultural research systems are expected to increasingly depend on integrated digital platforms that connect laboratories, field experiments, weather stations, genomic databases, policy analysis tools, and innovation networks in real time. Enhancing digital capacity will improve scientific productivity, facilitate multidisciplinary collaboration, strengthen monitoring and evaluation, and expedite the translation of research findings into practical solutions for both farmers and policymakers.

Table 6.3. Emerging Digital Technologies Transforming Agricultural Research

Digital Technology	Current Application in Agricultural Research	Strategic Importance	Key References
Artificial Intelligence	Predictive analytics, crop diagnostics, modelling	Very High	STISA-2034; World Bank (2023)
Remote Sensing and GIS	Land use mapping, soil monitoring, crop assessment	Very High	FAO (2022); ISRIC (2023)
Genomics and Bioinformatics	Crop and livestock improvement	High	CGIAR (2023)
Big Data and Cloud Computing	Research databases, modelling, knowledge management	High	OECD (2015)
Internet of Things (IoT)	Smart farming, sensor networks, environmental monitoring	Emerging	World Bank (2023)
Digital Soil Information Systems	Soil mapping, fertilizer recommendations, land planning	Very High	AUSO; ISRIC (2023)

6.5 The Agricultural Research Capacity Gap: Persistent Constraints to Scientific Excellence

Although agricultural research in Africa has advanced over the past three decades, substantial capacity constraints persist and limit the effectiveness of the Agricultural Research and Innovation System. These challenges include not only insufficient financial resources but also shortages of skilled personnel, outdated scientific infrastructure, weak institutional management, limited digital capabilities, and fragmented innovation ecosystems. Together, these factors exacerbate the **Agricultural Research Capacity Gap (ARCG)** and diminish the capacity of National Agricultural Research Systems (NARS) to produce the knowledge, technologies, and policy evidence necessary to achieve continental development objectives.

Part of the challenge is the ageing scientific workforce. Numerous national research organizations, founded during the expansion of public agricultural research in the 1970s and 1980s, now have a significant proportion of senior scientists nearing retirement. Recruitment of early-career researchers has not kept pace due to public sector hiring restrictions, constrained operational budgets, and the declining appeal of research careers. In the absence of intentional succession planning, institutions risk losing decades of accumulated scientific expertise and leadership.

Brain drain remains a persistent challenge. Highly trained African scientists often migrate to international organizations, universities, development agencies, or institutions outside Africa in

pursuit of better remuneration, enhanced research facilities, and improved career prospects. While the African scientific diaspora constitutes a valuable knowledge resource, ongoing outward migration undermines institutional continuity within many NARS. Future capacity-building strategies should aim both to retain talent and to implement mechanisms that engage the diaspora through joint appointments, visiting professorships, collaborative research programs, and virtual knowledge networks.

Organizational capacity is also limited by shortages of laboratory technicians, research managers, statisticians, data scientists, and innovation specialists. Although scientific expertise is essential, modern agricultural research increasingly depends on multidisciplinary teams that can manage complex research programs, coordinate partnerships, communicate scientific findings to policymakers, and facilitate technology commercialization. Enhancing these complementary skills is now as critical as expanding the number of researchers.

Gender disparities persist across numerous agricultural research institutions. While women's participation in agricultural science has increased significantly over the past two decades, women remain underrepresented in senior scientific and leadership roles, especially in engineering, biotechnology, agricultural mechanization, and quantitative sciences. Addressing these disparities will enhance equity and expand the diversity of perspectives that drive scientific innovation.

Table 6.4. Major Capacity Constraints Affecting Agricultural Research in Africa

Capacity Constraint	Current Situation	Impact on Research Performance	Strategic Response	Key References
Aging scientific workforce	A large proportion of senior researchers are nearing retirement	Loss of institutional memory and leadership	Succession planning and youth recruitment	ASTI/IFPRI (2024); Beintema and Stads (2017)
Brain drain	Continued migration of experienced scientists	Reduced national research capacity	Competitive career pathways and diaspora engagement	UNESCO (2021)
Limited technical support staff	Shortage of laboratory technicians and research assistants	Lower research efficiency and equipment utilization	Technical training and career development	FARA (2014)
Weak research management	Limited project, financial and innovation management skills	Reduced institutional effectiveness	Professional management development	OECD (2015)
Gender imbalance	Underrepresentation of women in senior scientific positions	Loss of scientific diversity and leadership	Gender-responsive recruitment and leadership Programs	UNESCO (2021)
Digital skills deficit	Limited expertise in AI, bioinformatics and advanced analytics	Reduced global competitiveness	Digital capacity development and continuous training	STISA-2034; World Bank (2023)

6.6 Emerging Competencies for the Next Generation of Agricultural Scientists

Agricultural research is undergoing rapid transformation. Future agricultural scientists must develop competencies that surpass traditional disciplines, including agronomy, animal science, crop protection, and soil science. The intersection of climate change, digital transformation, biotechnology, globalization, and food systems thinking necessitates researchers who can operate across both disciplinary and institutional boundaries.

Artificial intelligence and machine learning now support crop modelling, pest surveillance, precision nutrient management, and predictive analytics. Remote sensing and geospatial technologies facilitate continuous monitoring of land use, soil degradation, water resources, and crop performance. Genomics and bioinformatics accelerate crop and livestock improvement, while big data analytics and cloud computing enable advanced modelling and decision-support systems. Collectively, these technologies are transforming agricultural research into a data-intensive scientific enterprise.

In addition to technical expertise, future researchers must develop skills in innovation management, science communication, policy analysis, entrepreneurship, intellectual property management, research commercialization, and stakeholder engagement. Scientists are increasingly expected to generate knowledge, mobilize partnerships, influence policy, communicate research findings to diverse audiences, and facilitate technology adoption among farmers and agribusinesses.

These developments have significant implications for universities and National Agricultural Research Systems. Curricula should be updated to incorporate digital agriculture, systems thinking, climate science, data analytics, and innovation management alongside traditional agricultural disciplines. Strengthening experiential learning through internships, multidisciplinary research projects, industry partnerships, and regional scientific mobility programs is also essential.

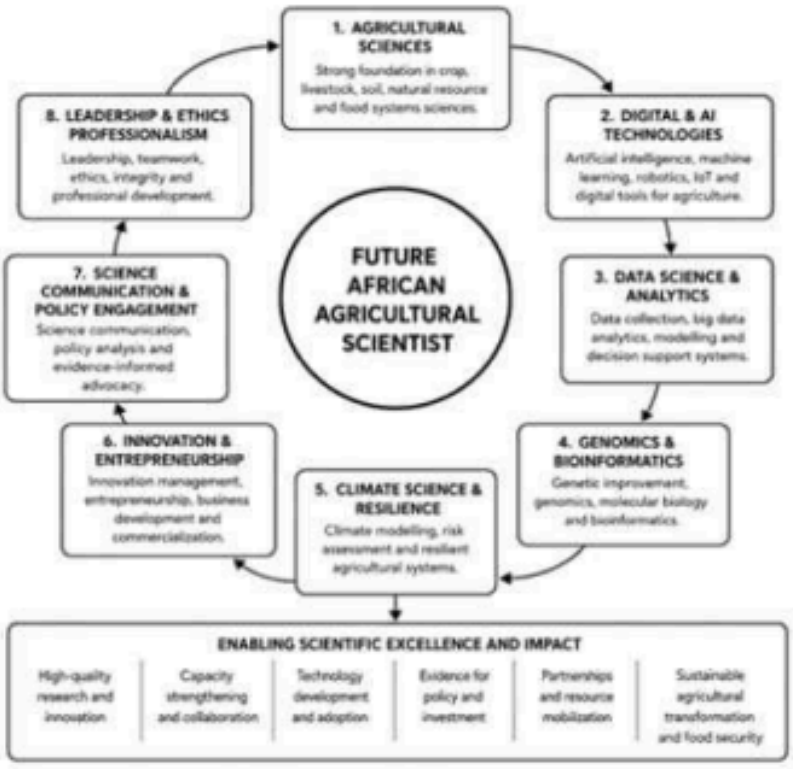


Figure 6.3. Required Competencies for the Future African Agricultural Scientist

6.7 Building Africa's Next Generation Agricultural Research Capacity

Closing the Agricultural Research Capacity Gap (ARCG) requires moving from fragmented training programs to sustained investment in people, institutions, infrastructure, and innovation ecosystems. Capacity development should reinforce the entire research system so it can generate, apply, and maintain scientific knowledge for agricultural transformation.

The top priority is to renew Africa's scientific workforce. Many National Agricultural Research Systems (NARS) have aging staff and need clear succession plans. Governments should increase postgraduate training, postdoctoral fellowships, competitive recruitment, and career development, while fostering work environments that retain talented young scientists.

Modernizing research infrastructure is also essential. Laboratories, experimental farms, biotechnology facilities, digital platforms, climate observation systems, and data centres should meet international standards. Instead of duplicating expensive facilities, Regional Economic Communities, Sub-Regional Organizations (SROs), and Centres of Excellence should encourage shared infrastructure and specialized analytical services.

Digital transformation should be central to capacity development. Investments in artificial intelligence, geospatial technologies, cloud computing, bioinformatics, digital soil information systems, open science platforms, and high-performance computing will enhance research quality and collaboration. Strengthening digital skills among scientists and research managers is essential. Universities should modernize agricultural curricula by including data science, climate modeling, innovation management, entrepreneurship, science communication, intellectual property, and policy engagement with traditional agricultural disciplines. Stronger partnerships with NARS, the private sector, and international research organizations will ensure graduates have the multidisciplinary skills needed for modern agricultural research.

Continental institutions such as the African Union Commission, AUDA-NEPAD, FARA, CGIAR, SROs, and regional university networks should continue to promote scientific mobility, postgraduate harmonization, collaborative research, and regional centers of excellence. Structured engagement with Africa's scientific diaspora through joint appointments, visiting professorships, mentoring, and collaborative research can turn brain drain into brain circulation, strengthening Africa's research capacity and expanding access to global scientific networks.

Table 6.6. Strategic Priorities for Strengthening Agricultural Research Capacity

Strategic Priority	Key Actions	Expected Outcome	Lead Institutions	Indicative References
Human capital renewal	Recruit young scientists, expand MSc/PhD training, mentorship Programs	Stronger scientific workforce and institutional continuity	NARS, Universities, Ministries	FARA (2014); RUFORUM (2024)
Infrastructure modernization	Upgrade laboratories, research farms, digital platforms and shared facilities	Improved research quality and competitiveness	Governments, AUDA-NEPAD, Development Partners	ASTI/IFPRI (2024); FAO (2022)
Digital transformation	Invest in AI, GIS, cloud computing, data governance and digital agriculture	Data-driven research and innovation	Universities, NARS, Private Sector	STISA-2034; World Bank (2023)
Regional collaboration	Strengthen Centers of Excellence, researcher mobility and shared infrastructure.	Greater efficiency and regional scientific integration	FARA, SROs, CGIAR	AU (2025); FARA (2014)
Gender and youth inclusion	Expand opportunities for women and early - career scientists	Diverse and resilient scientific workforce	Governments, Universities	UNESCO (2021)
Diaspora engagement	Joint appointments, visiting scholars and collaborative grants	Improved knowledge exchange and international partnerships	AU, Universities, NARS	AU (2025); OECD (2015)

Conclusion

Africa possesses the scientific foundation required to develop a globally competitive agricultural research system. The continent benefits from an expanding university sector, a growing community of highly trained scientists, increasingly advanced research institutions, and robust continental coordination mechanisms. However, persistent disparities in human capital, infrastructure, digital capabilities, and institutional capacity continue to constrain research performance and exacerbate the Agricultural Research Capacity Gap (ARCG).

This chapter demonstrates that strengthening agricultural research requires more than simply increasing the number of scientists or constructing new laboratories. Achieving sustainable research excellence depends on integrated investments in human capital, infrastructure, digital technologies, institutional leadership, and innovation ecosystems. Furthermore, enhanced collaboration among National Agricultural Research Systems, universities, CGIAR centres, Sub-Regional Organizations, FARA, governments, and the private sector is essential.

The future competitiveness of African agriculture will increasingly depend on the continent's capacity to train scientists who can integrate biological sciences with artificial intelligence, climate science, genomics, digital technologies, economics, entrepreneurship, and policy analysis. Developing such multidisciplinary expertise is essential for addressing complex challenges related to food security, climate change, soil degradation, biodiversity conservation, and agrifood system transformation.

Ultimately, the future of African agriculture will be shaped not only by the policies adopted or institutions established, but by the quality of scientists trained, the research environments created, and the innovation ecosystems sustained. The Agricultural Research Capacity Gap (ARCG) is not merely a measure of scientific deficiency; it reflects the continent's unrealized development potential. Closing this gap constitutes one of the most strategic investments for achieving agricultural transformation and fulfilling the aspirations of Agenda 2063.

CHAPTER 7

Performance, Impact and Returns to Agricultural Research in Africa

7.1 Measuring Agricultural Research Performance

The effectiveness of agricultural research is assessed primarily by the societal value it generates rather than the resources invested. Investments in scientists, laboratories, infrastructure, and research Programs are justified when they result in knowledge, technologies, innovations, and policies that enhance agricultural productivity, strengthen food systems, promote environmental sustainability, and support economic development. Consequently, measuring research performance is essential for ensuring accountability, informing investment decisions, and improving the effectiveness of National Agricultural Research Systems (NARS).

Traditionally, research performance has been evaluated using scientific outputs such as the number of publications, conference papers, patents, improved crop varieties, and postgraduate graduates. Although these indicators remain important as measures of scientific productivity, they offer only a partial assessment of research performance. The primary purpose of agricultural research is to address development challenges, not merely to produce scientific publications.

Contemporary evaluation frameworks differentiate among **inputs**, **outputs**, **outcomes**, and **impacts**. Inputs encompass funding, researchers, laboratories, and research infrastructure. Outputs include scientific publications, technologies, innovations, policy briefs, and trained personnel. Outcomes reflect technology adoption, institutional change, improved policies, and strengthened innovation systems. Impacts measure long-term changes in agricultural productivity, food security, environmental sustainability, rural incomes, employment, and national economic growth. This results-based approach aligns with continental frameworks such as the Kampala Declaration, Agenda 2063, STISA-2034, and the Sustainable Development Goals.

This chapter presents the concept of the **Agricultural Research Performance Deficit (ARPD)**.
Agricultural Research Performance Deficit (ARPD): ***The difference between the scientific outputs and development impacts that Africa's agricultural research system can generate and the outcomes it currently delivers because of constraints in investment, institutional capacity, technology scaling, policy implementation, and innovation systems.***

The ARPD should not be viewed as evidence of underperformance by Africa's scientists. Instead, it highlights systemic constraints that limit the efficiency of translating scientific knowledge into technologies, policies, and development outcomes. Recognizing this distinction shifts the focus from solely evaluating researchers to strengthening the broader Agricultural Research and Innovation System.

Figure 7.1. Components of Agricultural Research Performance Assessment

7.2 Scientific Outputs: Measuring Knowledge Generation

Scientific output is the primary indicator of research performance, as it demonstrates the ability of research institutions to generate, validate, and disseminate new knowledge. Publications, improved crop varieties, livestock breeds, soil management technologies, patents, digital tools, policy briefs, postgraduate graduates, and technical manuals collectively constitute the tangible products of agricultural research. These outputs underpin innovation, technology transfer, and broader development impact.

In the past two decades, Africa has experienced notable growth in scientific productivity. The expansion of universities, increased postgraduate training, enhanced regional collaboration, and investments by National Agricultural Research Systems (NARS), CGIAR centres, and continental organizations have contributed to a sustained increase in agricultural publications and research outputs. Regional initiatives coordinated by FARA, Sub-Regional Organizations (SROs), CGIAR, and

continental Programs have further strengthened collaborative research and expanded opportunities for African scientists to participate in global scientific discourse.
However, evaluating research performance solely based on publication counts provides an incomplete assessment. Scientific excellence depends not only on the quantity of publications but also on their quality, relevance, citation impact, and their contribution to addressing practical development challenges. High publication output does not guarantee improved agricultural productivity if research findings are inaccessible to farmers, policymakers, or the private sector. Contemporary research evaluation frameworks increasingly emphasize knowledge utilization in addition to knowledge generation.

Agricultural research outputs encompass more than journal articles. Improved crop varieties, integrated soil fertility management technologies, biological pest control methods, climate-smart production practices, digital advisory platforms, mechanization innovations, livestock vaccines, fertilizer recommendations, and evidence-based policy instruments frequently have greater societal impact than publications alone. Therefore, contemporary performance assessment should acknowledge the diversity of research products generated within the agricultural innovation system.

7.3 From Scientific Outputs to Agricultural Innovation

The value of agricultural research is realized only when scientific outputs are transformed into innovations that are adopted by farmers, agribusinesses, governments, and other stakeholders. This transition—from knowledge generation to practical application represents one of the most important determinants of research performance.

Africa has produced numerous examples of research-driven innovation. Improved maize, rice, cassava, wheat, cowpea, and sorghum varieties have contributed to increased agricultural productivity and strengthened food security across diverse agroecological zones. Biological control technologies have significantly reduced crop losses from invasive pests, while integrated soil fertility management practices have enhanced nutrient-use efficiency and improved soil health. Advances in livestock genetics, aquaculture, mechanization, digital agriculture, and climate-smart farming have similarly expanded the range of technologies available to African producers.

Continental initiatives have further accelerated innovation. The Technologies for African Agricultural Transformation (TAAT) Program has promoted the scaling of proven technologies across multiple countries. The African Union Soil Observatory (AUSO) and the Africa Soil Data Centre (ASDAC) are working towards strengthening digital soil information systems to support evidence-based land management. The Soils4Africa initiative aims to harmonize soil data standards, while the Soil Initiative for Africa (SIA) and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) are creating enabling policy environments for improved soil management. Likewise, Programs on forgotten and opportunity crops are expanding research into neglected species that contribute to nutrition, biodiversity conservation, and climate resilience.

Despite these achievements, the transition from research outputs to innovation remains uneven. Weak extension systems, limited private-sector engagement, fragmented seed systems, inadequate commercialization pathways, and insufficient investment in scaling continue to slow the widespread adoption of many research products. As a result, the development impact of agricultural research often falls below its scientific potential.

This observation reinforces the **Agricultural Research Performance Deficit (ARPD)** introduced in the earlier chapter. The challenge is not simply generating more knowledge, but creating stronger systems that convert knowledge into technologies, technologies into widespread adoption, and adoption into measurable improvements in productivity, livelihoods, and food system resilience.

Evidence Box 7.2. Africa's Greatest Research Challenge Is Scaling Innovation

Many agricultural technologies developed by African research institutions demonstrate strong technical performance under experimental conditions. However, comparatively fewer achieve widespread adoption at national or regional scale. Evidence suggests that the principal barriers lie not in scientific discovery but in technology dissemination, seed systems, extension services, market development, financing, and enabling policy environments. Future assessments of research performance should therefore evaluate not only scientific productivity but also the effectiveness of innovation scaling and commercialization pathways

Figure 7.2: Composition of Agricultural Research Outputs in Africa

Source: Compiled by author based on FARA (2014); ASTI/IFPRI (2024); CGIAR (2023); RUFORUM (2024).

7.4 Development Impact and Returns to Agricultural Research

The effectiveness of agricultural research is best assessed by its impact on improving livelihoods, rather than by the quantity of publications or technologies released. Value is created when research enhances agricultural productivity, strengthens food and nutrition security, increases farm incomes, restores degraded ecosystems, improves resilience to climate change, supports evidence-based policymaking, and stimulates economic growth. These outcomes constitute the genuine return on investment in agricultural research.

International studies consistently demonstrate that agricultural research yields some of the highest economic returns among public investments. Global meta-analyses estimate average annual rates of return between **20% and 60%**, depending on the commodity, technology, and production environment (Alston et al., 2000; Hurley et al., 2016). These benefits accrue over time as technologies are adopted, refined, and disseminated throughout farming systems. While relatively few continental studies have quantified comparable returns across Africa, existing evidence suggests that investments in crop improvement, integrated soil fertility management, livestock health, biological pest control, mechanization, and digital agriculture have produced substantial economic and social benefits.

One of Africa's prominent examples of research success in Africa is the development and dissemination of NERICA (New Rice for Africa) by the Africa Rice Center, which combined the high productivity of Asian rice with the resilience of African rice species. NERICA varieties have led to increased rice production, improved household food security, and reduced reliance on rice imports in several African countries. Similarly, drought-tolerant maize varieties developed through

collaborations involving CIMMYT and national research organizations have enhanced resilience in drought-prone regions of Eastern and Southern Africa. . The development of **Aflasafe** by the International Institute of Tropical Agriculture (IITA) has significantly reduced aflatoxin contamination in maize and groundnuts, improving food safety while increasing market opportunities for farmers. Integrated pest management technologies for cassava, maize, and horticultural crops have similarly reduced production losses and enhanced environmental sustainability by lowering dependence on chemical pesticides.

Recent continental initiatives underscore the increasing significance of coordinated innovation systems. The Technologies for African Agricultural Transformation (TAAT) program has shown that scaling proven technologies across multiple countries can substantially increase agricultural productivity when supported by effective partnerships among research institutions, governments, extension services, and the private sector. Similarly, the African Union Soil Observatory (AUSO), the Africa Soil Data Centre (ASDAC), the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) are enhancing digital soil information systems, standardizing soil data, and supporting evidence-based soil health policies to facilitate sustainable agricultural intensification.

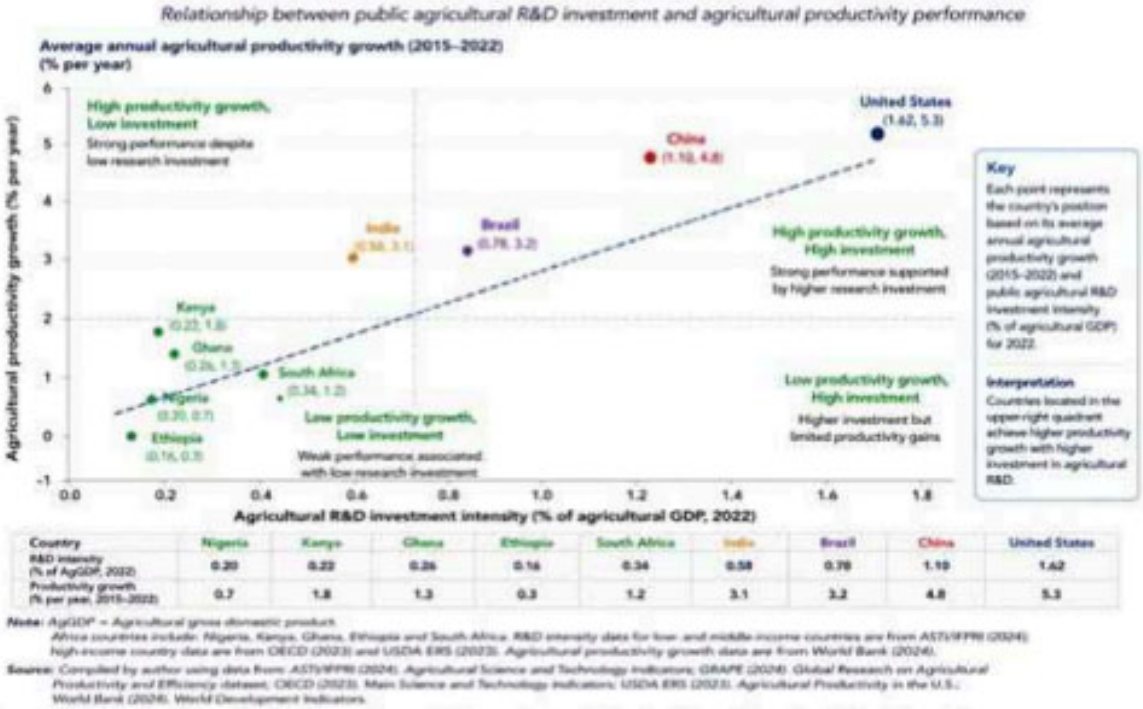
Agricultural research has made substantial contributions to policy development. Scientific evidence has informed fertilizer recommendations, seed regulations, biosafety frameworks, mechanization strategies, climate adaptation plans, food safety standards, and national agricultural investment plans under the Comprehensive Africa Agriculture Development Program (CAADP). Increasingly, research institutions are expected to generate technologies and provide strategic intelligence that enables governments to make informed policy decisions.

7.5 Factors Limiting the Full Impact of Research

Although significant achievements have been made, the development impact of agricultural research often does not reach its full potential. The primary challenge is not a lack of scientific capability, but rather the limited capacity of agricultural innovation systems to scale successful technologies broadly and efficiently. As a result, many promising innovations remain restricted to pilot projects or research stations, reaching only a small fraction of potential users.

Multiple factors contribute to this performance deficit. Weak extension systems restrict farmers' access to improved technologies, and fragmented seed systems limit the availability of enhanced planting materials. Insufficient private-sector engagement impedes commercialization, while inadequate access to finance prevents many farmers from adopting productivity-enhancing innovations. Additionally, policy inconsistency, weak market infrastructure, and poor coordination among research, extension, education, and agribusiness stakeholders further diminish the effectiveness of technology dissemination.

The Agricultural Research Performance Deficit (ARPD) thus represents a failure of systems rather than of science. Scientific discoveries alone are insufficient to transform agriculture without effective innovation ecosystems that connect researchers, universities, extension services, private enterprises, financial institutions, policymakers, and farming communities.
Future research evaluations should therefore prioritize technology adoption, farmer reach, policy influence, environmental sustainability, and socioeconomic impact, in addition to traditional indicators such as publications and patents. Assessing research based on development outcomes will yield a more comprehensive evaluation of agricultural science's contribution to Africa's transformation agenda.



Country	Nigeria	Kenya	Ghana	Ethiopia	South Africa	India	Brazil	China	United States
R&D intensity (% of AgGDP, 2022)	0.20	0.22	0.26	0.16	0.34	0.58	0.78	1.10	1.42
Productivity growth (% per year, 2015–2022)	0.7	1.8	1.3	0.3	1.2	3.1	3.2	4.8	5.3

Note: AgGDP = Agricultural gross domestic product.
Africa countries include: Nigeria, Kenya, Ghana, Ethiopia and South Africa. R&D intensity data for low- and middle-income countries are from ASTI/IFPRI (2024); high-income country data are from OECD (2023) and USDA ERS (2023). Agricultural productivity growth data are from World Bank (2024).

Source: Compiled by author using data from ASTI/IFPRI (2024), Agricultural Science and Technology Indicators; GRAPE (2024) Global Research on Agricultural Productivity and Efficiency dataset; OECD (2023), Main Science and Technology Indicators; USDA ERS (2023), Agricultural Productivity in the U.S.; World Bank (2024), World Development Indicators.

Figure 7.5: Agricultural R &D Investment Intensity and Agricultural Productivity Growth: Selected Countries, 2015-2022

Evidence Box 7.3. Research Excellence Must Be Measured by Development Outcomes

A growing international consensus recognizes that research performance should be evaluated not only by scientific productivity but also by societal impact. For Africa, where agricultural researchis expected to contribute directly to food security, employment, climate resilience, and economic transformation, indicators such as technology adoption, farmer productivity, policy uptake, environmental restoration, and private-sector innovation may provide more meaningful measures of success than publication counts alone. The transition from output-based evaluation to impact-based assessment represents one of the most important reforms needed to strengthen agricultural research performance across the continent.

CHAPTER

8 From Science to Impact: Agricultural Innovation Systems and Technology Delivery in Africa

Chapter Summary

This chapter examined how agricultural research is transformed into societal impact through Agricultural Innovation Systems (AIS). It introduced the**Agricultural Innovation Translation Gap (AITG)** to explain the disconnect between scientific discovery and widespread adoption of agricultural innovations. The chapter reviewed technology demand articulation, research priority setting, extension systems, technology dissemination, adoption pathways, commercialization, and intellectual property management. It argued that successful agricultural transformation depends on integrated innovation ecosystems linking researchers, universities, governments, the private sector, financial institutions, farmer organizations, and markets. Strengthening these partnerships will enable Africa to convert scientific excellence into competitive enterprises, improved livelihoods, resilient food systems, and sustained economic growth.

8.1 Agricultural Innovation Systems: Linking Scientific Advances to Development Outcomes

Agricultural research produces knowledge; however, knowledge by itself does not lead to agricultural transformation. Scientific discoveries generate value only when translated into technologies, adopted by end users, incorporated into policies, commercialized by enterprises, and maintained within effective innovation ecosystems. The progression from knowledge generation to societal impact is neither automatic nor linear. It necessitates ongoing collaboration among researchers, farmers, extension organizations, private companies, financial institutions, policymakers, civil society organizations, and consumers. This interconnected process constitutes the foundation of the Agricultural Innovation System (AIS).

The Agricultural Innovation System concept was developed in response to the limitations of the traditional linear research–extension–farmer model, which posited a one-way flow of innovations from scientists to end users. Although this model played a significant role in the Green Revolution, it needs some refocusing to address the increasingly complex agricultural challenges such as climate change, market integration, environmental sustainability, nutrition, digital agriculture, and evolving consumer preferences. Current approaches to agricultural innovation emphasize that knowledge is generated through interactions among diverse actors who collectively identify challenges, co-develop solutions, adapt technologies, and promote learning throughout the agrifood system (World Bank, 2012; Hall et al., 2006).

African countries have increasingly adopted the Agricultural Innovation Systems approach. Key policy frameworks, including the Science Agenda for Agriculture in Africa (S3A) developed by the Forum for Agricultural Research in Africa, the Comprehensive Africa Agriculture Development Program (CAADP), the Science, Technology and Innovation Strategy for Africa (STISA-2034), and the Kampala CAADP Declaration, all emphasize enhanced collaboration among research institutions, universities, extension services, farmer organizations, agribusinesses, financial institutions, development partners, and governments. These frameworks conceptualize research organizations not as isolated generators of knowledge, but as facilitators within broader innovation ecosystems that promote learning, technology adaptation, entrepreneurship, and policy reform.

This chapter presents the concept of the Agricultural Innovation Translation Gap (AITG).
Agricultural Innovation Translation Gap (AITG): ***The disparity between scientific knowledge generated by agricultural research and the extent to which it is translated into widely adopted technologies, commercial products, public policies, and measurable development outcomes.***

The AITG accounts for the persistence of scientifically robust innovations that remain limited to research stations, pilot projects, or academic publications despite their technical merit. Addressing this gap requires strengthening partnerships, improving technology delivery systems, promoting private-sector engagement, enhancing policy support, and establishing incentives for the adoption of innovation.

8.2 Technology Demand Articulation: Enhancing Research Responsiveness

Effective agricultural innovation is grounded in a clear understanding of user needs rather than laboratory-based approaches. Historically, agricultural research priorities were set primarily by scientists or government agencies, often leading to technologies that addressed scientific interests rather than urgent development challenges. Contemporary innovation systems increasingly acknowledge that successful research must respond to articulated demands from farmers, agribusinesses, processors, consumers, policymakers, and emerging market opportunities.

Technology demand articulation refers to the systematic process of identifying, analyzing, prioritizing, and communicating the technological needs of diverse stakeholders to guide research investment and innovation. This process ensures that research agendas address actual production constraints, market opportunities, environmental challenges, and societal priorities rather than solely institutional preferences. As a result, demand articulation enhances the relevance, ownership, and eventual adoption of research outputs.

In Africa, multiple mechanisms have emerged to facilitate the articulation of demand. Innovation platforms, commodity value-chain forums, farmer organizations, national agricultural investment planning processes, foresight studies, stakeholder consultations, living laboratories, and public-private dialogue platforms increasingly enable end users to influence research priorities. Through the Comprehensive Africa Agriculture Development Program (CAADP), many countries have integrated stakeholder consultations into the development of National Agricultural Investment Plans (NAIPs). Additionally, the Science Agenda for Agriculture in Africa promotes participatory priority setting as a core principle of agricultural research governance.

Digital technologies are transforming the process of demand articulation. Mobile applications, digital advisory platforms, online farmer surveys, geospatial monitoring systems, market intelligence tools, and artificial intelligence provide researchers with unprecedented access to real-time information on production constraints, climate risks, pest outbreaks, consumer preferences, and market demand. These technologies enable research organizations to respond more effectively and adaptively, thereby strengthening evidence-based priority setting. Despite these advancements, the demand for technology articulation remains inconsistent across the continent. Many research institutions continue to implement predominantly supply-driven research programs, and mechanisms for systematically capturing farmer demand, private-sector priorities, youth perspectives, and consumer preferences are often underdeveloped. Enhancing participatory foresight, horizon scanning, and multi-stakeholder engagement is therefore essential to improve the responsiveness of African agricultural research systems.

Table 8.1. Evolution of Agricultural Research Priority Setting in Africa

Research Paradigm	Primary Driver	Characteristics	Major Limitation	Emerging Best Practice	Key References
Scientist-driven	Research institutions	Curiosity-led, discipline-based research	Weak alignment with user needs	Integrate stakeholder engagement	Hall et al. (2006)
Government-driven	Ministries	National policy priorities	Political influence on resource allocation	Evidence-based planning	World Bank (2012)
Donor-driven	Development partners	Project-focused investments	Fragmented research agenda	Alignment with national priorities	OECD (2015)
Market-driven	Private sector	Commercial opportunities	Limited focus on public goods	Public-private partnerships	Spielman et al. (2011)
Demand-driven AIS	Multiple stakeholders	Co-creation, innovation platforms, foresight	Requires strong coordination	Preferred model for modern innovation systems	FARA (2014); AUC (2025)

Evidence Box : Innovation Begins with Demand

Experience from successful agricultural innovation programmes across Africa demonstrates that technologies developed through participatory priority-setting processes generally achieve higher adoption rates than those designed without user engagement. Innovation platforms, farmer-led experimentation, commodity value-chain partnerships, and stakeholder consultations help ensure that research investments address practical production constraints while strengthening ownership among technology users. Increasingly, effective research organizations are shifting from **technology push** approaches toward **demand-driven innovation systems**, where farmers, agribusinesses, and policymakers actively shape research agendas rather than merely receiving research outputs.

Figure 8.1. Agricultural Innovation System for Agricultural Transformation in Africa

8.3 Agricultural Research Priority Setting and Agenda Formation

The effectiveness of an agricultural research system depends fundamentally on its ability to invest in the right research at the right time. Priority setting is therefore one of the most strategic functions of National Agricultural Research Systems (NARS), determining how limited financial, human, and institutional resources are allocated among competing agricultural challenges. In an era characterized by climate change, rapid urbanization, demographic growth, digital transformation, biodiversity loss, and evolving consumer preferences, research agendas must remain dynamic and responsive to emerging development priorities.

Historically, agricultural research priorities in Africa were largely determined by government ministries, national research institutes, and international development partners. Although these approaches generated important scientific advances, they frequently reflected institutional mandates or donor priorities rather than the expressed needs of farmers, agribusinesses, processors, consumers, and local communities. The result was often a mismatch between research investments and development needs, contributing to slow technology adoption and limited research impact.

Contemporary agricultural research increasingly adopts participatory priority-setting approaches. These approaches recognize that effective research agendas emerge through structured dialogue among multiple stakeholders, including researchers, universities, farmer organizations, private companies, extension services, policymakers, civil society, financial institutions, and development partners. Rather than treating farmers as passive recipients of technology, participatory approaches position them as active partners in defining research questions, evaluating technologies, and shaping innovation pathways.

At the continental level, the Science Agenda for Agriculture in Africa (S3A) introduced a demand-led philosophy that encourages research organizations to align scientific investments with Africa's long-term agricultural transformation objectives. Similarly, the CAADP Kampala Declaration, STISA-2034, Agenda 2063, the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) collectively provide strategic frameworks that increasingly influence national research priorities. These continental commitments encourage countries to integrate climate resilience, soil health, nutrition, digital agriculture, youth employment, gender inclusion, mechanization, and agribusiness development into national agricultural research agendas.

Priority setting has also become increasingly evidence-based. Advances in geospatial analysis, digital soil information systems, climate modelling, market intelligence, artificial intelligence, and agricultural foresight now enable governments to identify emerging challenges before they become crises. This shift from reactive to anticipatory planning is transforming agricultural research from a discipline focused primarily on solving existing problems into one capable of preparing for future risks and opportunities.

Table 8.2. Evolution of Agricultural Research Priority Setting in Africa

Priority-setting approach	Principal decision makers	Strengths	Limitations	Current relevance	Representative references
Scientist-driven	NARS, Universities	Scientific excellence and disciplinary depth	Weak stakeholder ownership	Moderate	Hall et al. (2006)
Government-led	Ministries of Agriculture and Science	Alignment with national policies	Political influence and changing priorities	High	World Bank (2012)
Donor-led	Development partners	Access to financial resources and international expertise	Fragmentation and external influence	Moderate	OECD (2015)
Commodity/value chain-driven	Producer organizations, agribusinesses	Strong market orientation	May underinvest in public goods	Increasing	Spielman et al. (2011)
Innovation platform approach	Multi-stakeholder partnerships	Joint learning and co - creation	Coordination-intensive	High	FARA (2014)
Foresight and evidence-driven	Governments, NARS, regional bodies	Anticipatory, data-informed, strategic	Requires robust data systems	Very High	STISA-2034; AU (2025)

8.4 Mechanisms for Responding to Technology Demand

Identifying research priorities represents only the initial phase in establishing responsive innovation systems. Equally significant are the institutional mechanisms that convert identified needs into funded research programs, collaborative partnerships, technology development, and policy action. These mechanisms serve as the operational link between articulating technology demand and achieving scientific innovation.

Across Africa, multiple complementary mechanisms are increasingly employed to address technology demand. Innovation platforms enable ongoing dialogue among researchers, farmers, agribusinesses, extension agents, financial institutions, and policymakers, allowing stakeholders to define problems, test solutions, and evaluate technologies collaboratively. Commodity-specific innovation platforms for rice, maize, cassava, livestock, fisheries, and horticulture have demonstrated significant success in enhancing technology relevance and strengthening partnerships throughout agricultural value chains.

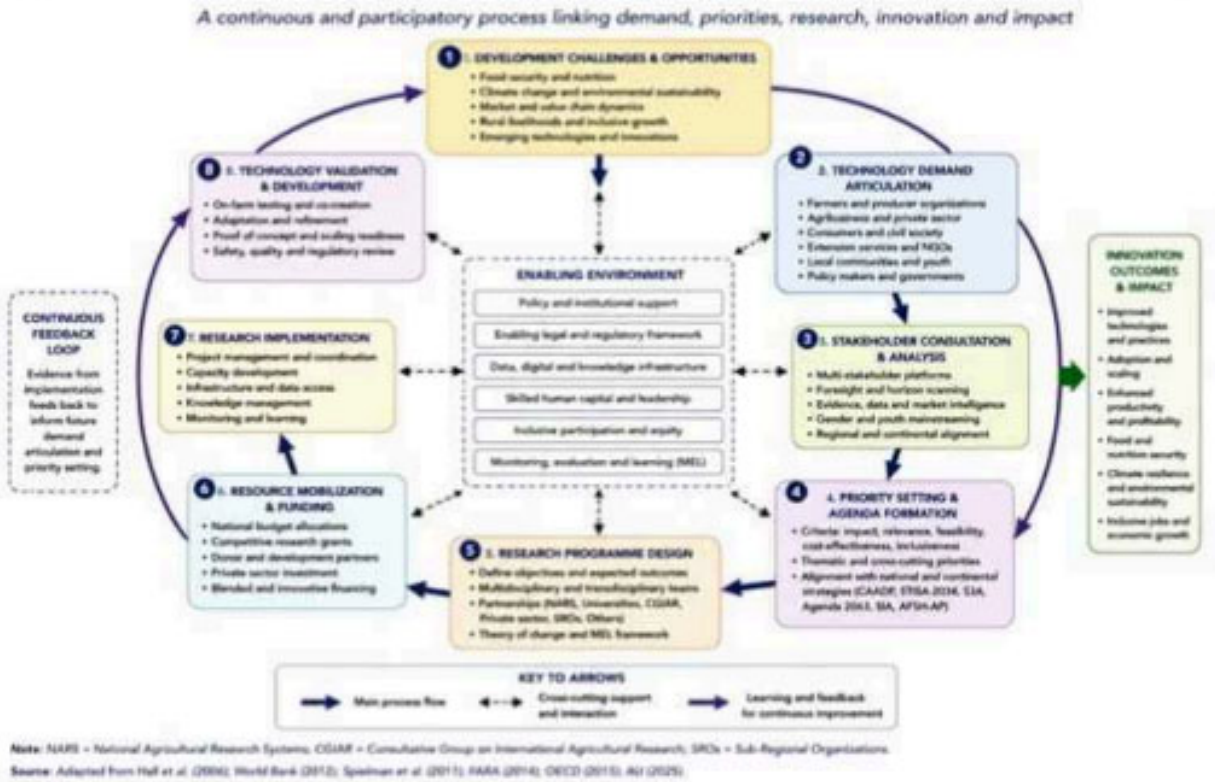
National Agricultural Research Systems are increasingly utilizing competitive research grants to foster multidisciplinary collaboration on nationally prioritized challenges. Such funding mechanisms promote scientific excellence and enable researchers from universities, research institutes, private companies, and civil society organizations to collectively address complex agricultural issues. At the continental level, programs coordinated by FARA, CGIAR, the SROs, and regional Centres of Excellence have similar advanced collaborative research on strategic themes, including soil health, climate-smart agriculture, mechanization, digital agriculture, and sustainable food systems.

Foresight and horizon-scanning exercises further strengthen responses to technology demand. These approaches integrate scenario analysis, expert consultation, modeling, and stakeholder engagement to identify emerging technologies, production risks, market opportunities, and policy priorities that are likely to influence African agriculture in the coming decades. An increasing number of countries are employing these methods to inform long-term investments in biotechnology, digital agriculture, artificial intelligence, genomics, renewable energy, circular bioeconomy, and resilient food systems.

However, institutional fragmentation continues to limit effective responses to technology demand. Inadequate coordination among research organizations, universities, extension services, ministries, and private-sector actors frequently delays technology development and diminishes research efficiency. Additionally, insufficient feedback mechanisms between technology users and researchers restrict opportunities for adaptive learning and ongoing improvement. Strengthening integrated innovation systems remains essential for enhancing research responsiveness and accelerating technology delivery.

Evidence Box :Priority Setting Determines Research Impact

International experience demonstrates that the quality of agricultural research is strongly influenced by the quality of its priority-setting processes. Countries that regularly review research agendas using stakeholder consultations, foresight studies, market intelligence, and scientific evidence are generally better positioned to respond to emerging challenges than those relying on static research programmes. For Africa, strengthening national prioritysetting systems will be essential for ensuring that research investments remain aligned with continental commitments under the Kampala Declaration, Agenda 2063, STISA-2034, the Soil Initiative for Africa, and the Africa Fertilizer and Soil Health Action Plan.



Note: NARS = National Agricultural Research Systems, CGIAR = Consultative Group on International Agricultural Research, SROs = Sub-Regional Organizations.

Source: Adapted from Hall et al. (2006); World Bank (2012); Spielman et al. (2011); FARA (2014); OECD (2015); AU (2025).

Figure 8.2. Agricultural Research Priority-Setting and Demand Response Framework

8.5 From Science to Impact: Technology Dissemination and Adoption

The generation of scientific knowledge marks the beginning rather than the conclusion of agricultural innovation. The value of research is fully realized only when new technologies, management practices, policies, and institutional innovations are adopted at scale by farmers, agribusinesses, processors, and policymakers. Technology dissemination thus serves as the essential link between scientific discovery and socioeconomic transformation.

Historically, agricultural technology dissemination in Africa followed a linear transfer-of-technology model in which researchers developed innovations, extension agents transferred knowledge, and farmers adopted recommended practices. While this model contributed significantly to early agricultural modernization, it has become increasingly inadequate for addressing the complexity of contemporary agricultural systems. Farmers operate under diverse ecological, economic, cultural, and institutional conditions that often require adaptation rather than straightforward technology transfer. As a result, modern innovation systems prioritize co-creation, learning, adaptation, and continuous feedback instead of one-way dissemination.

Currently, technology dissemination occurs through multiple channels that operate concurrently. Public extension services remain central in many countries, but they are increasingly supplemented by private advisory services, producer organizations, digital extension platforms, innovation platforms, agribusiness companies, non-governmental organizations, universities, and farmer-to-farmer learning networks. The rapid expansion of mobile technologies, artificial intelligence, remote sensing, digital advisory systems, and social media is transforming the generation, sharing, and application of agricultural information.

Continental initiatives increasingly reflect a systems perspective. Programs such as the Technologies for African Agricultural Transformation (TAAT), the Soil Initiative for Africa (SIA), the Africa Fertilizer and Soil Health Action Plan (AFSH-AP), the African Union Soil Observatory (AUSO), and digital soil information systems emphasize integrated approaches. These approaches combine research, policy support, private-sector engagement, extension, capacity development, and digital technologies to accelerate technology scaling.

8.6 Agricultural Extension and Technology Dissemination Systems

Agricultural extension remains a key mechanism for translating research into practice. Extension services perform functions that extend beyond information transfer, including farmer training, technology demonstration, adaptive experimentation, facilitation of farmer organizations, market linkage development, climate advisory services, and innovation brokerage. Extension agents increasingly serve as knowledge intermediaries who connect researchers, farmers, private companies, financial institutions, and policymakers.

Over the past five decades, Africa has implemented diverse extension models. Public extension systems remain dominant in many countries; however, resource constraints have reduced their coverage and effectiveness. In response, pluralistic extension systems have emerged, integrating public agencies with private advisory services, farmer organizations, agribusinesses, non-governmental organizations, digital platforms, universities, and community-based organizations. This diversification has expanded opportunities for technology dissemination but has also introduced new challenges related to coordination, quality assurance, and equitable access.

Digital agriculture is transforming the delivery of extension services. Mobile advisory services, smartphone applications, artificial intelligence, satellite-based decision-support tools, e-extension platforms, digital soil maps, climate information services, and online knowledge repositories enable farmers to access location-specific recommendations in real time. These innovations enhance the timeliness, relevance, and cost-effectiveness of extension while complementing, rather than replacing, conventional face-to-face advisory services.

However, significant challenges persist. Many extension systems continue to experience shortages of qualified personnel, inadequate operational funding, weak connections with research institutions, limited adoption of digital technologies, and insufficient engagement with youth and women. Addressing these constraints will require sustained investment in professional development, digital infrastructure, institutional coordination, and performance-based extension systems.

Table 8.3. Evolution of Agricultural Extension Systems in Africa

Extension Model	Main Characteristics	Strengths	Major Limitations	Emerging Trend	Representative References
Public extension	Government-funded advisory services	National coverage and public accountability	Limited operational resources and staffing	Continues to provide core services	Anderson and Feder (2007)
Training and Visit (TandV)	Structured extension visits	Standardized information dissemination	Limited farmer participation	Largely replaced by participatory models	World Bank (1994)
Farmer Field Schools	Participatory learning and experimentation	Strong capacity development and local adaptation	Resource intensive	Widely adopted for sustainable agriculture	FAO (2016)
Private advisory services	Commercial extension linked to value chains	Market-oriented and demand-responsive	Limited access for resource - poor farmers	Expanding rapidly	Davis and Franzel (2018)
Digital extension	Mobile platforms, AI, remote sensing	Large-scale, real-time advisory services	Digital divide and infrastructure gaps	Fastest-growing extension model	World Bank (2023); FAO (2022)
Agricultural Innovation Systems	Multi-actor learning, co - creation and partnerships	Integrated technology development and scaling	Requires strong coordination	Preferred continental model	FARA (2014); World Bank (2012)

8.7 Adoption of Agricultural Technologies in Africa

Technology adoption serves as a key indicator of research relevance and the effectiveness of innovation systems. Scientifically robust technologies have limited developmental impact when restricted to research stations or demonstration plots. Therefore, identifying the factors that influence technology adoption is critical for enhancing agricultural research performance.

Adoption is shaped by a complex interplay of technical, economic, institutional, social, and behavioral factors. Farmers assess technologies based on yield improvement, profitability, risk,

labor requirements, market access, compatibility with existing farming systems, cultural preferences, gender considerations, and access to credit and inputs. Technologies that address these broader decision-making criteria typically achieve higher adoption rates than those optimized exclusively for biological performance.

Empirical studies consistently show that adoption rates increase when technologies are developed through participatory approaches involving farmers, extension agents, private companies, and local communities. These approaches enhance the relevance of technology and strengthen user ownership and adaptive learning. Digital decision-support systems, demonstration plots, innovation platforms, farmer field schools, producer organizations, and lead farmer networks further promote technology diffusion by supporting peer-to-peer learning and knowledge exchange.

Despite substantial progress, adoption rates for many agricultural technologies remain below their potential in several African countries. Weak extension systems, limited access to quality seed and inputs, insufficient rural finance, inadequate market infrastructure, fragmented value chains, and inconsistent policy environments continue to constrain widespread technology uptake. Addressing these challenges requires integrated innovation systems that connect research, finance, markets, extension, and policy into coherent technology delivery pathways.

Evidence Box : Adoption Is a Systems Outcome

Evidence from agricultural innovation programs across Africa consistently shows that successful technology adoption depends less on the intrinsic quality of a technology than on the strength of the surrounding innovation ecosystem. Effective extension services, functioning input markets, access to finance, supportive policies, private-sector participation, and strong farmer organizations collectively determine whether scientific discoveries achieve widespread impact. Consequently, improving adoption requires investment in entire innovation systems rather than in technology development alone.

8.8 Ownership, Intellectual Property and Commercialization of Agricultural Innovations

The adoption of agricultural technologies marks a significant milestone in the innovation process; however, it does not represent the ultimate goal. Achieving sustainable agricultural transformation necessitates the progression of scientific discoveries into commercially viable products, competitive enterprises, and profitable value chains that generate employment, attract private investment, and support long-term economic growth. As a result, commercialization has become an increasingly prominent aspect of agricultural research systems globally.

Historically, agricultural research institutions have prioritized the generation of public goods, such as improved crop varieties, agronomic practices, livestock technologies, natural resource management strategies, and policy advice. Although these functions remain essential, fiscal constraints and increased private-sector involvement have broadened expectations for research organizations to contribute to enterprise development, value addition, technology licensing, and innovation-driven entrepreneurship. The primary challenge is to balance the public-good mandate of agricultural research with opportunities for sustainable commercialization.

Intellectual property (IP) serves as a critical mechanism for protecting and managing innovations, thereby encouraging investment in research and technology development. Agricultural innovations can be safeguarded through patents, plant breeders' rights, trademarks, geographical indications, copyrights, trade secrets, and licensing agreements, depending on the specific technology. Robust IP systems incentivize innovation by granting legal recognition to inventors and facilitating technology transfer through structured licensing and partnership arrangements.

In many African countries, the utilization of intellectual property remains limited within National Agricultural Research Systems (NARS). Numerous publicly funded institutions continue to release technologies without clearly defined commercialization pathways, leading to weak technology licensing, limited private-sector adoption, and underutilization of research outputs. Furthermore, inadequate institutional policies, insufficient legal expertise, and underdeveloped technology transfer offices frequently hinder the effective management of intellectual property generated through publicly funded research.

Commercialization does not equate to the privatization of agricultural research. Instead, it is a strategic process that transforms suitable innovations into products, services, and enterprises generating economic and social value. Technologies that serve the public good, such as those addressing food security, climate resilience, natural resource conservation, and poverty reduction, should remain broadly accessible. In contrast, commercially viable innovations can generate additional revenue streams, thereby enhancing research sustainability and promoting agribusiness development.

8.9 Agricultural Innovation Systems and Commercialization Pathways

Successful commercialization relies on robust innovation ecosystems rather than isolated efforts by individual research organizations. Universities, NARS, private companies, financial institutions, incubators, venture capital, farmer organizations, regulatory agencies, and technology transfer offices collectively facilitate the transition of innovations from laboratories to markets.

Agricultural innovation systems are increasingly establishing innovation incubators, technology parks, business accelerators, and research commercialization units that offer technical support for product development, intellectual property management, market analysis, business planning, and enterprise creation. These institutions facilitate collaboration among researchers, entrepreneurs, investors, manufacturers, and agribusinesses throughout the commercialization process.

The private sector is essential for scaling agricultural innovations. Seed companies multiply and distribute improved varieties, machinery manufacturers adapt and commercialize mechanization technologies, digital enterprises develop advisory platforms, fertilizer companies formulate enhanced nutrient products, and food processors generate new market opportunities for agricultural commodities. Public-private partnerships are among the most effective mechanisms for translating research outputs into sustainable economic activities.

Continental initiatives are providing growing support for commercialization. Programs implemented by FARA, CGIAR, the SROs, AUDA-NEPAD, AfDB, and regional innovation networks prioritize entrepreneurship, technology scaling, youth employment, digital agriculture, climate-smart agribusiness, and market-oriented innovation. These initiatives acknowledge that agricultural transformation depends not only on scientific excellence but also on dynamic innovation ecosystems that attract investment and foster competitive enterprises.

Table 8.4. Pathways for Commercializing Agricultural Research in Africa

Commercialization pathway	Typical products	Principal actors	Expected outcomes	Representative references
Technology licensing	Improved varieties, software, diagnostic tools	NARS, universities, private firms	Revenue generation and wider technology dissemination	WIPO (2022)
Public-private partnerships	Seeds, fertilizers, mechanization, digital agriculture	Governments, research institutions, agribusiness	Technology scaling and investment	World Bank (2012)
Business incubation	Agri-startups, biotechnology, digital services	Universities, innovation hubs	Enterprise creation and youth employment	OECD (2015)
Farmer-led enterprises	Community seed systems, processing, cooperatives	Farmer organizations, NGOs	Local value addition and inclusive growth	FAO (2022)
Innovation platforms	Multi-stakeholder technology development	FARA, SROs, CGIAR, NARS	Accelerated innovation and adoption	FARA (2014)
Spin-off companies	Commercial technologies from research institutions	Universities, research institutes	Sustainable commercialization and research income	AUTM (2023)

8.10 The Future of Agricultural Innovation Systems in Africa

Africa is at a critical juncture in the development of its agricultural research and innovation systems. Recent advances in artificial intelligence, biotechnology, precision agriculture, genomics, digital advisory services, robotics, remote sensing, climate analytics, and big-data science are transforming the generation and application of agricultural knowledge. These technologies present significant opportunities to enhance research efficiency, refine technology targeting, accelerate innovation cycles, and increase resilience within African food systems.

Future innovation systems are expected to rely increasingly on open science, interdisciplinary collaboration, and digital knowledge platforms that connect researchers, policymakers, entrepreneurs, and farmers across national borders. Agricultural research institutions must transition from solely producing knowledge to serving as innovation brokers by convening partnerships, managing intellectual assets, facilitating commercialization, and supporting entrepreneurial ecosystems.

The development of African-owned innovation financing mechanisms, such as the proposed African Agricultural Research Endowment Fund, innovation challenge funds, blended finance instruments, venture capital, and impact investment, is also essential. Sustainable financing will enable African institutions to pursue strategic, long-term research agendas and decrease reliance on externally determined priorities.

The future competitiveness of African agriculture will depend not only on the generation of new scientific knowledge but also on the development of integrated innovation systems that can continuously transform knowledge into technologies, technologies into enterprises, and

enterprises into inclusive economic growth. Addressing the Agricultural Innovation Translation Gap (AITG) necessitates coordinated investments in research, extension, education, digital infrastructure, private-sector engagement, and supportive public policies.

Evidence Box 8.4. Innovation Is Africa's Next Competitive Advantage

The future of African agriculture will be determined less by the quantity ofscientific knowledge produced than by the effectiveness with which that knowledge is translated into widely adopted innovations, competitive enterprises, and sustainable livelihoods. Countries that successfully integrate research, education, finance, entrepreneurship, extension, digital technologies, and policy into coherent agricultural innovation systems will be better positioned to achieve food security, climate resilience, industrial development, and economic transformation.

CHAPTER
9

The Future of Agricultural Research in Africa: Emerging Technologies, New Frontiers and Strategic Transformation

Chapter Summary
This chapter explored the future of agricultural research in Africa through the lens of emerging technologies, digital transformation, biotechnology, and institutional modernization. It introduced the concepts of the **Agricultural Research Transformation Index (ART)** and the **Africa Agricultural Research Transformation Framework (AARTF)**to guide the modernization of National Agricultural Research Systems. The chapter argued that future agricultural competitiveness will depend upon integrated bio-digital research systems, artificial intelligence, regional collaboration, sustainable financing, commercialization, and evidence-based policymaking. Together, these elements provide a strategic roadmap for transforming African agricultural research from a knowledgegenerating enterprise into a globally competitive engine of innovation, economic growth, and sustainable food systems

9.1 A New Era for Agricultural Research

Agricultural research is undergoing a profound transformation. The integration of artificial intelligence, biotechnology, genomics, robotics, digital agriculture, climate science, remote sensing, advanced computing, and systems biology is fundamentally altering how scientific knowledge is generated, analyzed, and applied. These technologies accelerate scientific discovery, enhance the precision of agricultural interventions, and enable researchers to address complex challenges that were previously unattainable through conventional research methods.

For Africa, these advancements represent both a significant opportunity and a strategic necessity. The continent's rapidly increasing population, expanding urban areas, climate variability, land degradation, biodiversity loss, shifting dietary preferences, and evolving labor dynamics demand research systems capable of generating solutions with greater speed, scale, and precision. Consequently, future agricultural competitiveness will depend more on the capacity of research institutions to integrate emerging technologies into multidisciplinary innovation systems than on the sheer volume of research conducted.

Agricultural research has historically advanced through a series of scientific revolutions. The initial phase focused on crop improvement via conventional breeding. The Green Revolution marked the second phase, characterized by enhanced germplasm, fertilizer application, irrigation, and mechanization. The third phase introduced biotechnology, molecular genetics, and information technologies. Currently, agriculture is entering a **Fourth Agricultural Research Revolution**, defined by the convergence of biological sciences with artificial intelligence, digital platforms, automation, advanced analytics, and integrated environmental monitoring. This convergence is shifting agricultural research from a primarily experimental discipline to a data-intensive, predictive, and increasingly autonomous scientific system.

Africa has already initiated participation in this transformation. The creation of continental initiatives such as the **African Union Soil Observatory (AUSO)**, digital soil information systems, climate-smart agriculture programs, precision agriculture initiatives, digital extension platforms, geospatial monitoring systems, and continental agricultural data platforms reflects increasing recognition that future agricultural competitiveness will rely on scientific digitalization. However, the rate of technological adoption varies significantly among countries, underscoring the need for coordinated investment, institutional reform, and strategic capacity development.

This chapter introduces the **concept of the Agricultural Research Transformation Index (ARTI).**
Agricultural Research Transformation Index (ARTI): ***A composite framework designed to assess the readiness of National Agricultural Research Systems to generate, integrate, commercialize, and scale science-driven innovations by leveraging emerging technologies, modern research infrastructure, digital capabilities, and collaborative innovation ecosystems.***

In contrast to earlier concepts presented in this book, ARTI is not solely intended to identify deficiencies. Instead, it offers a forward-looking framework that enables countries to benchmark progress toward establishing globally competitive agricultural research systems capable of advancing Africa's long-term transformation agenda.

9.2 Emerging Technologies Transforming Agricultural Research

The future of agricultural research will be shaped by technologies that integrate biological, digital, engineering, and environmental sciences. These technologies operate synergistically, creating new opportunities for scientific discovery and technological advancement.

Artificial intelligence and machine learning enable researchers to analyze large datasets, predict crop performance, identify disease outbreaks, optimize breeding programs, and support evidence-based decision-making. Advances in remote sensing, satellite imagery, and unmanned aerial vehicles (UAVs) facilitate continuous monitoring of crops, soils, water resources, and ecosystem health at high spatial and temporal resolution. High-performance computing allows scientists to simulate climate scenarios, model nutrient cycling, evaluate policy options, and forecast agricultural production with greater accuracy.

Biotechnology and genomics continue to accelerate crop and livestock improvement through genomic selection, molecular diagnostics, gene editing, microbiome research, and precision breeding. Concurrently, the Internet of Things (IoT), sensor networks, robotics, autonomous machinery, and digital twins are transforming agricultural experimentation by enabling real-time monitoring of biological processes and automated management of field trials.

The emergence of integrated digital knowledge platforms is equally significant. Open-access databases, cloud computing, interoperable information systems, and continental data infrastructures facilitate collaboration among researchers across institutions and countries. These platforms support reproducible science, evidence synthesis, and multidisciplinary research, while reducing duplication of effort and improving the efficiency of agricultural research systems.

For Africa, these technologies provide opportunities to enhance research productivity and address persistent structural challenges. Digital platforms can compensate for limited extension capacity, remote sensing can improve monitoring across extensive landscapes, artificial intelligence can support advisory services in multiple local languages, and continental data infrastructures can facilitate regional collaboration while reducing the costs associated with scientific research.

Table 9.1. Emerging Technologies Reshaping Agricultural Research

Emerging Technology	Current Global Maturity	Readiness in Africa	Potential Application	Strategic Priority	Representative References
Artificial Intelligence	High	Emerging	Predictive analytics, advisory systems, modelling	Very High	FAO (2024); OECD (2024)
Machine Learning	High	Emerging	Disease prediction, yield forecasting	Very High	Nature Machine Intelligence
Remote Sensing and Earth Observation	High	Moderate	Crop monitoring, soil mapping, climate assessment	Very High	FAO; ESA
Robotics and Automation	Moderate	Limited	Precision agriculture, phenotyping, mechanization	High	World Economic Forum
Internet of Things (IoT)	Moderate	Emerging	Smart irrigation, sensor networks	High	World Bank (2023)
Genomics and Gene Editing	High	Moderate	Crop improvement, livestock breeding	Very High	CGIAR (2024)
Digital Twins	Emerging	Low	Farm system simulation and scenario analysis	Medium	OECD (2024)
Big Data and Cloud Computing	High	Emerging	Knowledge management, modelling, open science	Very High	World Bank (2023)
Blockchain	Emerging	Low	Traceability, seed certification, value chains	Medium	FAO (2024)
Quantum Computing*	Experimental	Very Low	Future optimization and systems modelling	Long-term	Nature (2024)

Evidence Box 9.1. Africa Has the Opportunity to Leapfrog

Unlike previous agricultural revolutions, many emerging technologies are digital rather than infrastructure-intensive. Cloud computing, artificial intelligence, satellite imagery, open-source software, digital soil mapping, and mobile advisory systems reduce the need for expensive physical infrastructure while expanding access to advanced scientific capabilities. This creates an unprecedented opportunity for African countries to leapfrog intermediate stages of technological development and establish modern research systems built around digital knowledge, regional collaboration, and open innovation rather than traditional laboratory-intensive models. Realizing this opportunity will require coordinated investments in digital infrastructure, human capital, data governance, and institutional transformation.

Note: *The technologies are interdependent and reinforce one another. Their convergence creates a new paradigm for discovery, innovation and delivery of solutions for agrifood systems transformation in Africa.*

Source: *Adapted from FAO (2024); OECD (2024); CGIAR (2024); World Bank (2023); WEF (2024); Nature (2024).*

9.3 Artificial Intelligence, Big Data and Digital Agriculture

Artificial Intelligence (AI) is rapidly becoming one of the most transformative technologies in agricultural science. In contrast to earlier technological advances that focused on improving data collection or mechanizing field operations, AI fundamentally alters the processes by which scientific knowledge is generated, analyzed, interpreted, and applied. Technologies such as machine learning, deep learning, natural language processing, computer vision, and generative AI enable researchers to analyze complex datasets, identify previously undetected patterns, generate predictive models, automate scientific workflows, and accelerate discovery at an unprecedented pace.

Traditionally, agricultural research has relied on sequential processes such as hypothesis formulation, field experimentation, statistical analysis, publication, and technology dissemination. While this approach is scientifically rigorous, it often requires several years for research findings to impact agricultural practice. Artificial intelligence significantly reduces this timeframe by enabling rapid analysis of large, multidimensional datasets collected from sources including satellites, drones, field sensors, weather stations, genomics laboratories, mobile devices, markets, and national statistical systems. As a result, researchers can identify emerging trends, evaluate alternative scenarios, and support evidence-based decision-making in near real time.

The rapid expansion of digital agriculture has generated an unprecedented volume of agricultural data. Satellite imagery provides continuous observations of crop growth, vegetation health, soil moisture, land degradation, and climatic variability. Sensor networks monitor environmental conditions at the farm level, while mobile technologies deliver real-time information on farmer behavior, market transactions, extension services, and technology adoption. These diverse data streams form the foundation for AI systems to learn, improve, and produce increasingly accurate predictions.

In Africa, AI offers a unique opportunity to address persistent structural constraints in agricultural research. Many countries face shortages of highly specialized scientists, inadequate laboratory infrastructure, fragmented datasets, and limited extension capacity. When effectively implemented, AI can augment human expertise by enhancing analytical efficiency, supporting decision-making, expanding access to scientific knowledge, and strengthening collaboration across institutions. Digital platforms further enable countries with limited research infrastructure to engage in global scientific networks through cloud computing and open-access knowledge systems.

However, AI cannot replace scientific judgment. Reliable predictions require high-quality data, robust scientific methodologies, transparent algorithms, and ethical governance. Developing trusted AI systems therefore necessitates investments in data quality, digital infrastructure, interdisciplinary expertise, and institutional capacity.

9.4 Intelligent Agricultural Research Systems (IARS): The Next Evolution of NARS

The rise of artificial intelligence marks a shift from conventional National Agricultural Research Systems to Intelligent Agricultural Research Systems (IARS). Whereas traditional research systems generate knowledge mainly through experimentation and observation, IARS integrates human expertise with advanced computational capabilities to establish adaptive, data-driven, and continuously learning research ecosystems.

An Intelligent Agricultural Research System incorporates artificial intelligence, big data analytics, cloud computing, digital laboratories, remote sensing, geographic information systems, genomics, digital soil information systems, and decision-support platforms into routine scientific operations. Instead of operating as isolated technologies, these digital capabilities interact continuously, allowing researchers to analyze large-scale datasets, automate repetitive tasks, optimize experimental design, predict emerging threats, and enhance technology targeting.

Across Africa, several continental initiatives are establishing the foundation for such systems. The African Union Soil Observatory (AUSO), the Africa Soil Data Center (ASDAC), the Soils for Africa program, climate information systems, digital extension platforms, and national geospatial infrastructures collectively serve as early components of an emerging continental digital research ecosystem. As interoperability advances, these initiatives may develop into integrated knowledge infrastructures that support real-time research, policy analysis, and innovation throughout African countries.

Artificial intelligence is transforming scientific collaboration. Large language models support researchers in literature synthesis, experimental design, statistical coding, and scientific writing. Machine learning algorithms accelerate genomic selection and crop breeding. Computer vision enhances pest diagnosis, while predictive analytics facilitates drought forecasting, disease surveillance, nutrient management, and agricultural risk assessment. These technologies improve

research efficiency and enable scientists to focus more on hypothesis development, innovation design, and strategic thinking.**Evidence Box 9.2. Artificial Intelligence Will Augment, Not Replace, Agricultural Scientists**

Artificial intelligence excels at analysing large datasets, identifying complex patterns, and automating repetitive analytical tasks. However, scientific creativity, ethical judgement, experimental design, stakeholder engagement, and strategic leadership remain fundamentally human responsibilities. The future agricultural research system will therefore depend not on replacing scientists with machines but on creating collaborative environments where researchers and intelligent digital systems work together to accelerate scientific discovery and innovation.

9.5 Biotechnology, Genomics and Precision Agriculture

While artificial intelligence is transforming the analytical aspects of agricultural research, advances in biotechnology and genomics are fundamentally reshaping the biological foundations of agricultural innovation. Contemporary biological sciences enable researchers to analyze plant, animal, microbial, and soil systems with exceptional precision, thereby accelerating the development of improved crop varieties, livestock breeds, biofertilizers, biological pest management technologies, and climate-resilient production systems.

During the past three decades, molecular biology has transformed agricultural science. Marker-assisted selection, genomic sequencing, genome-wide association studies, molecular diagnostics, and high-throughput phenotyping have significantly reduced the time required to identify desirable genetic traits and develop improved varieties. More recently, genome editing technologies such as **CRISPR-Cas systems** have enabled precise modification of plant and animal genomes, facilitating improvements in drought tolerance, pest resistance, nutrient-use efficiency, nutritional quality, and adaptation to changing climatic conditions.

African research institutions, including national organizations, universities, CGIAR centers, and regional Centers of Excellence, are increasingly engaged in the biological revolution. These entities employ molecular breeding, tissue culture, genomics, bioinformatics, and biotechnology to support crop improvement programs for maize, cassava, rice, cowpea, banana, sorghum, millet, wheat, legumes, and horticultural crops. In livestock research, the adoption of genomic selection, molecular diagnostics, vaccine development, and reproductive technologies has advanced efforts to improve animal productivity and disease resistance. The future of biotechnology extends beyond genetics. Enhanced understanding of soil microbiomes, plant-microbe interactions, rhizosphere ecology, and soil biodiversity is shifting soil science from a focus on chemical fertility to an emphasis on biological ecosystem functioning. Advances in microbial inoculants, biological nitrogen fixation, biofertilizers, and regenerative soil management are anticipated to become central to sustainable agricultural intensification in Africa.

9.6 Precision Agriculture and Integrated Bio-Digital Research Systems

Precision agriculture embodies the integration of biological sciences, engineering, digital technologies, and environmental monitoring into comprehensive agricultural management systems. Instead of applying uniform management practices across entire farms or landscapes, precision agriculture utilizes spatially explicit information to optimize the management of crops, soils, livestock, water, nutrients, and inputs based on local conditions.

Recent developments in satellite remote sensing, drones, artificial intelligence, geographic information systems, digital soil mapping, autonomous machinery, sensor technologies, and Internet of Things (IoT) devices have substantially improved the accuracy of agricultural system monitoring and management. Farmers now receive field-specific recommendations for fertilizer application, irrigation scheduling, pest management, variety selection, and harvesting, all informed by continuously updated environmental data.

In the African context, precision agriculture is not limited to large-scale commercial farming. Digital innovations can be tailored to smallholder farming systems through mobile advisory services, digital soil maps, community weather stations, shared mechanization services, drone-based extension, and artificial intelligence-powered decision-support systems. These approaches enhance resource-use efficiency and reduce production risks for millions of smallholder farmers.

The convergence of biological and digital sciences has led to the emergence of **Integrated Bio-Digital Agricultural Research (IBDAR)** : *A multidisciplinary research paradigm that integrates biotechnology, genomics, microbiology, artificial intelligence, digital agriculture, remote sensing, engineering, and systems* modeling *into a unified scientific platform for accelerating agricultural innovation and sustainable food system transformation.*

The IBDAR paradigm marks a significant shift from traditional disciplinary research. Instead of treating crop breeding, soil science, climate research, engineering, economics, and data science as separate fields, IBDAR promotes integrated research teams capable of addressing complex agricultural challenges through systems thinking and technological convergence.

Evidence Box 9.3. The Future of Agricultural Science Is Bio-Digital
Historically, agricultural disciplines evolved largely independently, with plant breeding, soil science, engineering, climatology, economics, and extension functioning as separate research domains. Future agricultural research will increasingly depend upon the integration of these disciplines through digital technologies, artificial intelligence, genomics, advanced analytics, and systems modelling. Countries capable of building such integrated research ecosystems will be better positioned to generate transformative innovations, accelerate technology development, and strengthen resilience across rapidly changing agrifood systems.

9.7 Africa Agricultural Research Transformation Framework (AARTF)

Previous chapters have established that Africa possesses considerable scientific talent, expanding institutional networks, increasing regional collaboration, and a progressively supportive continental policy environment for agricultural research. However, persistent constraints remain, such as insufficient financing, fragmented innovation systems, limited research infrastructure, shortages of skilled personnel, weak commercialization pathways, and slow technology adoption. Collectively, these challenges limit the ability of agricultural research to fully support food security, economic growth, and climate resilience.

Addressing these challenges requires more than incremental reform; it necessitates a comprehensive transformation of Africa's agricultural research ecosystem. Accordingly, this chapter introduces the **Africa Agricultural Research Transformation Framework (AARTF)** as a strategic roadmap to modernize National Agricultural Research Systems and position Africa as a global leader in agricultural science and innovation.

The AARTF acknowledges that future research competitiveness will rely on scientific excellence, institutional agility, digital capability, regional integration, private-sector engagement, and sustained political commitment. The framework is grounded in the principles of the **CAADP Kampala Declaration**, **Agenda 2063**, **STISA-2034**, the **Science Agenda for Agriculture in Africa**

(S3A), the **Soil Initiative for Africa (SIA)**, the **Africa Fertilizer and Soil Health Action Plan (AFSH-AP)**, and the **Sustainable Development Goals (SDGs). It also integrates** emerging technological advancements, including artificial intelligence, genomics, precision agriculture, and digital research infrastructures.

Instead of mandating a uniform institutional model, the framework offers a flexible structure that enables countries to strengthen research systems based on their unique capacities, priorities, and development objectives.

9.8 The Ten Pillars of Agricultural Research Transformation

The Africa Agricultural Research Transformation Framework is structured around ten interdependent strategic pillars that collectively define the attributes of a modern, resilient, and globally competitive agricultural research system.

Pillar 1. Sustainable African Financing

African countries are encouraged to increase domestic investment in agricultural research incrementally and to establish innovative financing mechanisms, such as national agricultural research funds, blended finance instruments, competitive grants, and the proposed African Agricultural Research Endowment Fund. Sustainable financing is essential for achieving long-term scientific independence.

Pillar 2. Human Capital and Scientific Leadership

Future research systems will require multidisciplinary scientists who can integrate biological sciences, engineering, economics, data science, policy analysis, and entrepreneurship. Ongoing investment in postgraduate education, leadership development, mentorship, and international collaboration will be critical.

Pillar 3. Modern Research Infrastructure

Laboratories, field research stations, digital repositories, genomic facilities, high-performance computing centers, digital soil laboratories, and shared regional infrastructure must become integral components of Africa's scientific ecosystem.

Pillar 4. Digital Transformation

Artificial intelligence, cloud computing, digital agriculture, remote sensing, Internet of Things technologies, and integrated data platforms should be routinely incorporated into agricultural research and innovation systems.

Pillar 5. Biotechnology and Precision Agriculture

Africa should increase investments in genomics, molecular breeding, gene editing, bioinformatics, microbiome research, and precision agriculture to accelerate the development of climate-resilient, nutrition-sensitive, and environmentally sustainable production systems.

Pillar 6. Strengthened National Agricultural Research Systems

National Agricultural Research Systems should develop into agile, multidisciplinary institutions that can coordinate research across universities, extension organizations, private-sector partners, and international research networks.

Pillar 7. Integrated Agricultural Innovation Systems

Research organizations should increasingly serve as innovation brokers, facilitating partnerships among farmers, agribusinesses, financial institutions, policymakers, civil society, and regional organizations to accelerate technology dissemination and commercialization.

Pillar 8. Regional Integration and Continental Coordination

The African Union, AUDA-NEPAD, FARA, CGIAR, Sub-Regional Organizations (CORAF, ASARECA, CCARDESA, and NASRO), regional economic communities, and universities should enhance collaborative research, harmonize standards, and facilitate knowledge sharing across countries.

Pillar 9. Commercialization and Private-Sector Engagement

Research systems should actively promote technology licensing, business incubation, innovation parks, agritech startups, public-private partnerships, and value-chain development, while preserving the public-good functions of agricultural research.

Pillar 10. Foresight, Monitoring and Evidence-Based Policy

National agricultural research systems should institutionalize foresight studies, horizon scanning, digital monitoring systems, impact evaluation, and evidence-based policy support to anticipate emerging challenges and to continuously enhance research performance.

9.9 Agricultural Research Transformation Index (ARTI)

To facilitate implementation of the transformation framework, this chapter introduces the **Agricultural Research Transformation Index (ARTI)** as a continental benchmarking instrument.

The Agricultural Research Transformation Index (ARTI) is a *multidimensional framework designed to assess the readiness, capability, and performance of National Agricultural Research Systems in generating, integrating, commercializing, and scaling science-based innovations that advance sustainable agricultural transformation.*

In contrast to conventional research indicators that focus on publications, budgets, or staffing, ARTI evaluates the overall transformation readiness of agricultural research systems across multiple dimensions.

The proposed framework includes six assessment domains:

1. **Research Capacity** – human resources, infrastructure, and institutional capability.
2. **Innovation Readiness** – technology development, partnerships, and commercialization.
3. **Digital Maturity** – artificial intelligence, data governance, interoperability, and digital infrastructure.
4. **Policy Responsiveness** – alignment with national and continental development agendas.
5. **Research Impact** – technology adoption, productivity, climate resilience, and societal outcomes.
6. **Sustainability** – domestic financing, governance, inclusiveness, and long-term institutional resilience.

ARTI is not intended to replace existing initiatives such as ASTI; rather, it is designed to complement them by evaluating the broader transformation of agricultural research systems. In the future, FARA, the African Union Commission, AUDA-NEPAD, and regional partners could jointly develop ARTI.

Evidence Box 9.4. From Research Dependence to Research Leadership

Africa's future competitiveness will depend not only on adopting global technologies but also on generating scientific discoveries that address thecontinent's own agricultural challenges while contributing to global knowledge. Building such leadership requires sustained investment in people, institutions, infrastructure, digital capabilities, innovation ecosystems, and Africanowned financing mechanisms. The transformation of agricultural research should therefore be viewed not as a sectoral intervention but as a strategic investment in Africa's longterm economic sovereignty and food system resilience.

CHAPTER 10 Toward Agricultural Research Sovereignty in Africa: A Continental Roadmap for Scientific Leadership and Agricultural Transformation

"The future belongs to nations that generate knowledge, not merely those that consume it. Agricultural research is therefore not simply an investment in science; it is an investment in sovereignty, resilience, and national prosperity."

10.1 Key Insights from the State of Agricultural Research in Africa

The preceding chapters have analyzed the evolution, institutional architecture, financing mechanisms, human capacity, innovation systems, performance, and future prospects of agricultural research in Africa. Collectively, these analyses indicate that the continent has achieved substantial progress in establishing agricultural research institutions, enhancing regional collaboration, expanding postgraduate education, and formulating continental policy frameworks that acknowledge science, technology, and innovation as critical drivers of agricultural transformation. However, significant structural weaknesses persist, limiting the capacity of agricultural research to fully support food security, economic growth, climate resilience, and sustainable development.

A key finding of this review is that Africa possesses considerable scientific talent, but faces challenges stemming from fragmented research systems and chronic underinvestment. Over the past five decades, African countries have established National Agricultural Research Systems (NARS), strengthened universities and faculties of agriculture, expanded collaboration with CGIAR centres, and developed regional coordinating mechanisms such as the Forum for Agricultural Research in Africa (FARA) and Sub-Regional Organizations (CORAF, ASARECA, CCARDESA, and NASRO). Collectively, these institutions form one of the largest scientific networks on the continent. Nevertheless, their effectiveness is often compromised by inadequate financing, outdated infrastructure, weak institutional coordination, limited commercialization pathways, and reliance on externally funded research Programs.

The review also demonstrates that agricultural research has become increasingly integral to Africa's continental development agenda. Policy frameworks such as the CAADP Kampala Declaration, Agenda 2063, STISA-2034, the Science Agenda for Agriculture in Africa (S3A), the Soil Initiative for Africa (SIA), and the Africa Fertilizer and Soil Health Action Plan (AFSH-AP) collectively acknowledge that agricultural transformation relies on robust scientific systems capable of generating technologies, informing policy, enhancing resilience, and improving livelihoods. However, implementation remains inconsistent across countries, underscoring the persistent gap between policy ambition and institutional capacity.

A recurring theme throughout this book is that the primary challenge confronting African agricultural research is not the generation of scientific discoveries, but the effective translation of these discoveries into practice. Numerous technologies, including improved crop varieties, livestock innovations, integrated soil fertility management practices, biological pest control, digital advisory systems, and climate-smart agriculture, have achieved significant technical success. However, their adoption and commercialization remain limited due to weaknesses in extension systems, private-sector engagement, financing, regulatory frameworks, and innovation ecosystems. Bridging this science-to-impact gap necessitates stronger collaboration among researchers, universities, governments, agribusinesses, financial institutions, and farming communities.

Another important lesson relates to the evolving nature of agricultural research. Scientific excellence is no longer measured solely by publications, experimental trials, or the number of technologies released. Future research systems will increasingly be assessed based on their contributions to productivity growth, climate adaptation, soil health, nutrition, industrial development, environmental sustainability, employment generation, and inclusive economic growth. Consequently, agricultural research is shifting from a focus on technology generation to an emphasis on systems transformation.

A significant conclusion from this review is that Africa is entering a new scientific era. Advances in artificial intelligence, digital agriculture, biotechnology, genomics, remote sensing, precision agriculture, advanced analytics, and integrated innovation systems are transforming how agricultural knowledge is generated and applied. These technological developments offer Africa an unprecedented opportunity to bypass traditional development pathways and establish research systems that are digitally connected, scientifically competitive, and globally relevant. Achieving this potential will require sustained political commitment, long-term investment, institutional modernization, and increased African ownership of agricultural research agendas.

The concepts presented throughout this book, Agricultural Research Implementation Gap (ARIG), Agricultural Research Investment Paradox (ARIP), Agricultural Research Capacity Gap (ARCG), Agricultural Research Performance Deficit (ARPD), Agricultural Innovation Translation Gap (AITG), and the Agricultural Research Transformation Index (ARTI) collectively illustrate the interconnected nature of the challenges facing African agricultural research. Addressing these challenges requires systemic, rather than isolated, interventions. Financing alone cannot transform agricultural research without capable institutions; infrastructure cannot generate impact without skilled scientists; innovation cannot succeed without enabling policies; and scientific excellence cannot lead to development without effective commercialization and technology dissemination systems. These lessons converge on a single overarching conclusion: the future of African agriculture is fundamentally linked to the future of African agricultural research. Countries that invest strategically in science, innovation, digital transformation, and human capital will be better positioned to achieve food security, climate resilience, industrial competitiveness, and economic sovereignty than those that continue to rely primarily on imported technologies and externally driven research agendas.

Evidence Box 10.1. Agricultural Research Is aStrategic Investment in Sovereignty
Countries that lead global agricultural innovation are characterized by sustained domestic investment in science, strong universities, effective research institutions, dynamic private sectors, and long-term political commitment to knowledge generation. For Africa, strengthening agricultural research is therefore not merely a sectoral priority but a strategic pathway toward food sovereignty, technological independence, economic resilience, and continental competitiveness.Scientific capability should increasingly be recognized as a core pillar of national development and regional integration.

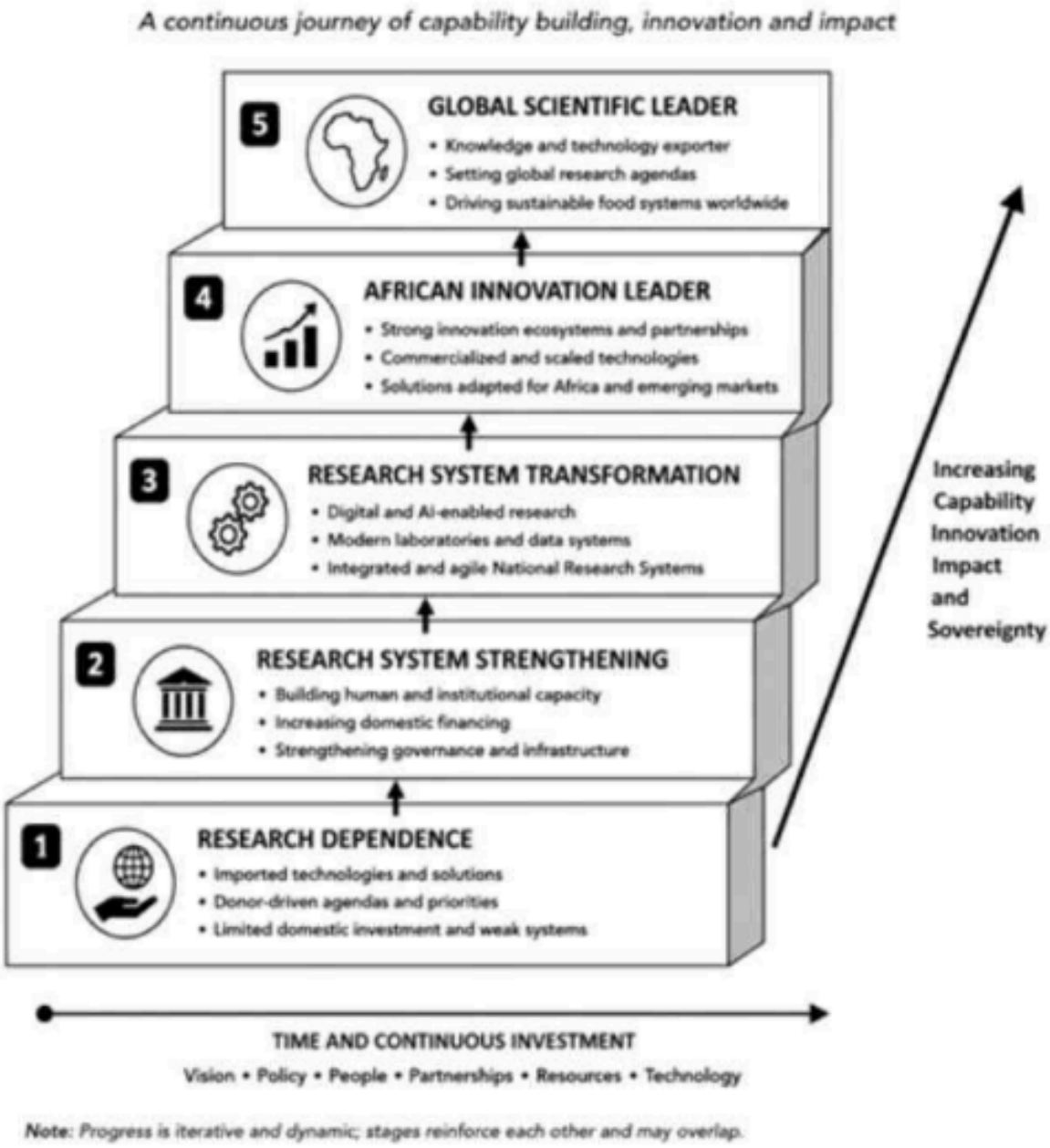


Figure 10.1. Evolution of African Agricultural Research: From Dependence to Scientific Leadership

10.2 A Continental Roadmap for Agricultural Research Transformation (2025–2050)

Transforming Africa's agricultural research systems requires more than isolated projects or short-term interventions. Scientific institutions develop over decades through sustained investment in human capital, infrastructure, governance, partnerships, and innovation. Countries currently leading global agricultural science, such as Brazil, China, the Netherlands, Australia, and the United States, achieved scientific leadership through long-term national commitments to research capacity, institutional continuity, and strategic financing. Africa similarly requires an ambitious and coordinated vision.

The proposed roadmap acknowledges that African countries vary in institutional maturity. Some have well-established National Agricultural Research Systems, advanced universities, and regional research leadership, while others face significant challenges in financing, infrastructure, staffing,

and governance. Therefore, the roadmap is structured as a flexible continental framework, enabling countries to progress according to national circumstances while remaining aligned with shared continental objectives.

The roadmap consists of three sequential phases. The first phase focuses on **strengthening national research systems**, the second emphasizes **continental integration and innovation**, and the third aims to position Africa as a **global leader in agricultural science and technology**. These phases are cumulative, with progress in each phase establishing the foundation for subsequent phases.

Phase I (2025–2030): Strengthening National Agricultural Research Systems
The immediate priority for African countries is to consolidate the institutional foundations of agricultural research. This phase emphasizes increasing domestic financing, modernizing research infrastructure, expanding postgraduate education, strengthening governance, improving laboratory facilities, investing in digital infrastructure, and enhancing collaboration among research institutes, universities, extension organizations, and the private sector.
Countries are encouraged to prioritize the implementation of commitments outlined in the **CAADP Kampala Declaration**, **Agenda 2063**, **STISA-2034**, the **Science Agenda for Agriculture in Africa**, the **Soil Initiative for Africa**, and the **Africa Fertilizer and Soil Health Action Plan**. Special emphasis should be placed on strengthening National Agricultural Research Systems as the primary institutional mechanism for coordinating research, innovation, and technology dissemination at the national level.

Digital transformation should begin in this phase through investments in broadband connectivity, cloud computing, digital repositories, interoperable research databases, geospatial information systems, artificial intelligence readiness, and national agricultural data governance frameworks. At the same time, governments should establish sustainable financing mechanisms to reduce reliance on externally funded projects and enhance long-term research stability.

Phase II (2030–2040): Building an Integrated Continental Agricultural Innovation System
After national systems are strengthened, the focus should shift to deeper continental integration. In this phase, Africa should establish interoperable research infrastructures, harmonized scientific standards, regional centers of excellence, shared digital platforms, coordinated postgraduate training networks, and collaborative innovation programs spanning multiple countries.

The Forum for Agricultural Research in Africa (FARA), Sub-Regional Organizations (CORAF, ASARECA, CCARDESA, and NASRO), AUDA-NEPAD, the African Union Commission, CGIAR centers, universities, and regional economic communities should enhance joint research programming, technology validation, and policy support. Continental initiatives such as the African Union Soil Observatory (AUSO), the Africa Soil Data Centre (ASDAC), digital agriculture platforms, climate information services, and open-access research repositories should achieve full interoperability, enabling real-time scientific information exchange across institutions and countries.

The private sector should play a significantly greater role in this phase by expanding investment in biotechnology, seed systems, digital agriculture, precision farming, mechanization, food processing, agricultural biotechnology, and innovation incubation. Universities should further integrate entrepreneurship, technology transfer, and intellectual property management into postgraduate training to produce graduates capable of establishing research-based enterprises in addition to pursuing scientific careers.

Phase III (2040–2050): Positioning Africa as a Global Scientific Leader

The long-term objective extends beyond strengthening African research systems to establishing Africa as a globally recognized center of agricultural science and innovation. At this stage, African institutions should increasingly define international research agendas, export scientific knowledge, license technologies internationally, attract global research investment, and contribute substantially to addressing global agricultural challenges.

Future National Agricultural Research Systems should function as intelligent, digitally connected organizations that integrate artificial intelligence, advanced biotechnology, digital laboratories, high-performance computing, precision agriculture, systems modeling, and predictive analytics into routine scientific practice. Agricultural innovation ecosystems should support globally competitive agritech enterprises while enhancing food security, environmental sustainability, and industrial development throughout the continent.

Equally important, Africa should increasingly finance its own research priorities. Establishing sustainable domestic financing, including the proposed **African Agricultural Research Endowment Fund, will enable** African institutions to pursue strategic long-term research agendas aligned with continental priorities rather than primarily responding to externally determined funding opportunities. Scientific sovereignty will thus become a defining characteristic of Africa's future agricultural research landscape.

Table 10.2. Continental Roadmap for Agricultural Research Transformation(2025–2050)

Transformation Phase	Strategic Priorities	Lead Institutions	Expected Outcomes
2025–2030Strengthening National Systems	Increase domestic financing; modernize laboratories; strengthen NARS; digital infrastructure; postgraduate training; improve governance	National Governments, Ministries of Agriculture and Science, NARS, Universities	Strong institutional foundations, improved research capacity, greater financial sustainability
2030–2040Continental Integration	Shared research infrastructure; regional centres of excellence; interoperable data systems; innovation platforms; private - sector partnerships	African Union, AUDA-NEPAD, FARA, SROs, CGIAR, RECs	Integrated African Agricultural Innovation System, accelerated technology development and scaling
2040–2050Global Scientific Leadership	AI-enabled research, biotechnology, commercialization, international technology licensing, African research financing, global partnerships	African research institutions, governments, private sector, continental organizations	Africa recognized as a global producer of agricultural science, innovation, and technology

Evidence Box 10.2. Transformation Requires Continuity

Experience from leading agricultural research systems demonstrates that scientific excellence is built through sustained investment over decades rather than isolated projects. Longterm political commitment, predictable financing, institutional stability, and strategic leadership are more important than short-term funding increases. For Africa, achieving agricultural research transformation will therefore require continuity of vision across successive governments, stronger regional cooperation, and consistent implementation of continental commitments.

10.3 Institutional Responsibilities for Agricultural Research Sovereignty

The effective implementation of the Continental Agricultural Research Transformation Roadmap depends on clearly defined institutional responsibilities. Agricultural transformation cannot be accomplished by research organizations acting independently, nor can governments alone deliver the necessary scientific, technological, financial, and policy reforms. Progress requires coordinated action among continental institutions, regional organizations, national governments, universities, research institutes, private enterprises, farmer organizations, and development partners.

A principal finding of this review is that institutional fragmentation continues to be a significant constraint on agricultural research performance in Africa. Overlapping mandates, duplication of programs, inconsistent financing, weak knowledge sharing, and limited coordination frequently diminish the effectiveness of otherwise capable institutions. Therefore, future agricultural research systems should operate as coordinated networks rather than as isolated organizations.

The concept of Agricultural Research Sovereignty outlined in this chapter is based on the principle of **shared leadership**. Continental organizations are responsible for providing strategic direction, regional organizations for coordinating implementation, national institutions for generating scientific solutions, universities for developing human capital, the private sector for commercializing innovation, and farmer organizations for ensuring that research remains responsive to development needs. Each institution offers distinct comparative advantages and collectively reinforces the resilience of the continental agricultural innovation ecosystem.

African Union Commission (AUC)

The African Union Commission should continue providing political leadership and continental policy direction for agricultural research and innovation. Its primary responsibility is to position agricultural science as a strategic pillar of Agenda 2063, the CAADP process, STISA-2034, and broader continental development agendas. The Commission should champion increased domestic investment in agricultural research, promote harmonized policy frameworks, and strengthen political accountability for implementation.

AUDA-NEPAD

AUDA-NEPAD should serve as the principal implementation agency for continental agricultural research initiatives. It should coordinate multi-country investment Programs, facilitate resource mobilization, strengthen monitoring and evaluation, and support the domestication of continental frameworks. AUDA-NEPAD should also lead the development of continental digital public goods, regional innovation infrastructure, and cross-border scientific initiatives.

Forum for Agricultural Research in Africa (FARA)

FARA should continue to serve as Africa's continental technical coordination platform for agricultural research and innovation. In addition to knowledge brokerage, FARA should increasingly function as the continent's **Strategic Technical Support Organization (TSO)** for agricultural research policy, foresight, innovation systems, research capacity development, digital transformation, monitoring and evaluation, and science diplomacy.

FARA is uniquely positioned to coordinate continental research agendas, facilitate collaboration among Sub-Regional Organizations, strengthen National Agricultural Research Systems, support Agricultural Innovation Systems, manage strategic knowledge platforms, and promote evidence-informed policymaking. FARA should also play a central role in developing the proposed **Agricultural Research Transformation Index (ARTI)** and in facilitating periodic continental assessments of research system performance.

Sub-Regional Organizations (CORAF, ASARECA, CCARDESA and NASRO)

Sub-Regional Organizations should function as operational platforms that connect continental priorities with national implementation. Their comparative advantage includes coordinating transboundary research, harmonizing scientific standards, facilitating regional Centres of Excellence, supporting technology validation across agroecological zones, and strengthening regional postgraduate education networks.

Enhanced collaboration among Sub-Regional Organizations will reduce duplication of research investments and accelerate the transfer of technologies across national boundaries.

National Governments

Governments are the primary custodians of national agricultural research systems. Their key responsibilities include increasing domestic financing, strengthening governance, modernizing research infrastructure, improving research careers, and creating policy environments that foster innovation, private-sector investment, and commercialization.

Long-term political commitment is essential. Sustainable research systems cannot rely solely on externally financed projects; they require predictable domestic investment supported by coherent national science policies.

National Agricultural Research Systems (NARS)

National Agricultural Research Systems should transition from collections of research institutes to integrated national knowledge systems that connect universities, extension organizations, private enterprises, farmer organizations, digital innovation platforms, and policy institutions.

Future NARS sFuture National Agricultural Research Systems should become increasingly data-driven, multidisciplinary, digitally enabled, and internationally connected, while maintaining strong responsiveness to national development priorities.

Higher Education Institutions

Universities are the principal source of Africa's future scientific workforce. Their responsibilities extend beyond postgraduate training to encompass frontier research, entrepreneurship development, technology incubation, innovation management, interdisciplinary collaboration, and lifelong professional development. Curricula should integrate artificial intelligence, digital agriculture, biotechnology, climate science, systems modeling, innovation management, intellectual property, and agribusiness entrepreneurship alongside conventional agricultural disciplines.

CGIAR Centers

CGIAR centers should continue to provide frontier science, global germplasm, advanced research infrastructure, and international scientific collaboration. Greater emphasis should be placed on co-designing research with African institutions, strengthening technology transfer, supporting capacity development, and facilitating joint leadership of international research programs.

Private Sector

The private sector should serve as a strategic co-investor rather than solely as a technology user. Agribusinesses, biotechnology companies, digital enterprises, financial institutions, seed companies, machinery manufacturers, food processors, and innovation startups all play critical roles in scaling technologies, creating employment, attracting investment, and strengthening commercialization pathways. Public-private partnerships should become a defining characteristic of future agricultural research systems.

Farmer Organizations

Farmer organizations should transition from being beneficiaries of research to becoming active innovation partners. Their participation in demand articulation, technology evaluation, adaptive experimentation, dissemination, and policy dialogue enhances research relevance and increases technology adoption.

Development Partners

Development partners will continue to make valuable contributions through financing, technical assistance, knowledge exchange, and international collaboration. Future partnerships should increasingly support **African-led priorities**, strengthen domestic institutions, and build sustainable national capacity rather than establishing parallel implementation systems.

Evidence Box 10.3. Institutions Matter More Than Projects

Many agricultural research initiatives have produced important scientific outputs but limited long-term institutional transformation because they were implemented as timebound projects rather than as components of enduring research systems. Sustainable scientific leadership depends on strong institutions that outlive individual projects, governments, and funding cycles. Building Agricultural Research Sovereignty therefore requires strengthening institutional relationships, governance systems, and African ownership of research priorities as much as expanding financial investment or technological capacity

Development Frontier for Africa

Historically, nations that have achieved sustained agricultural transformation share a defining characteristic: strategic investment in domestic scientific capacity. Examples include the agricultural modernization programs in the United States and Western Europe, as well as significant transformations in Brazil, China, India, Japan, and the Republic of Korea. In each case, long-term agricultural productivity has been supported by robust research institutions, domestic investment, technological innovation, and political commitment to science. As a result, scientific capability is now recognized as a critical determinant of agricultural competitiveness and national prosperity.

Africa is currently at a comparable historical juncture. The continent is endowed with abundant natural resources, significant biodiversity, a youthful population, expanding universities, dynamic entrepreneurial communities, and one of the fastest-growing food markets globally. Despite these strengths, much of Africa's agricultural development remains reliant on technologies, research funding, scientific equipment, and innovation priorities originating outside the continent. While international collaboration has played a substantial role in advancing agricultural development, sustained dependence on externally driven scientific systems restricts Africa's capacity to address its own priorities and influence global agricultural innovation.

Evidence presented in this review indicates that the future of African agriculture is fundamentally linked to the advancement of African agricultural research. Outcomes such as food security, soil health, climate resilience, industrialization, nutrition, rural employment, and export competitiveness depend on societies that can continuously generate, adapt, and apply scientific knowledge. Consequently, agricultural research should be regarded not only as a technical endeavor but also as strategic national infrastructure, comparable to transportation systems, energy networks, digital connectivity, and public health institutions.

Accordingly, this chapter introduces the concept of **Agricultural Research Sovereignty (ARS).**
Agricultural Research Sovereignty (ARS) refers to *the capacity of African countries and institutions*

to independently determine agricultural research priorities, mobilize sustainable domestic financing, generate globally competitive scientific knowledge, develop transformative technologies, commercialize innovations, and apply science to advance food security, climate resilience, environmental sustainability, industrial development, and economic prosperity through African-led institutions and partnerships.

Agricultural Research Sovereignty does not entail scientific isolation or diminished international collaboration. Instead, it promotes deeper global partnerships based on scientific strength, mutual respect, and shared leadership. Scientific sovereignty is defined by the institutional capacity to participate as an equal partner in global knowledge generation, rather than serving primarily as a recipient of externally determined technologies and research agendas.

10.6 Transitioning from Research Dependence to Global Scientific Leadership

Progress toward Agricultural Research Sovereignty necessitates a significant transformation in Africa's development trajectory. Historically, many African research systems have concentrated on adapting technologies developed externally. Although adaptation remains important, future competitiveness will depend on moving beyond adaptation to achieve original scientific discovery, technological innovation, and knowledge export.

This transformation can be conceptualized as occurring in five successive stages.

The first stage, research dependence, is characterized by limited domestic financing, fragmented institutions, and a strong reliance on imported technologies and externally funded research programs.

The second stage, research capability, involves strengthening National Agricultural Research Systems, universities, scientific infrastructure, postgraduate education, and institutional governance.

The third stage, innovation leadership, is marked by research that generates commercially viable technologies, supports agribusiness development, strengthens Agricultural Innovation Systems, and attracts private-sector investment.

The fourth stage, scientific competitiveness, is characterized by African institutions contributing to frontier research, influencing international scientific agendas, and participating as equal partners in global innovation networks.

The final stage, Agricultural Research Sovereignty, is achieved when African countries collectively become significant exporters of agricultural knowledge, technologies, digital solutions, scientific services, and innovations, while maintaining resilient, self-sustaining research systems financed primarily through African resources and strategic international partnerships.

Realizing this vision will require sustained political commitment that extends beyond electoral cycles and short-term development projects. The maturation of research institutions occurs over decades, and scientific leadership relies on stable investment, institutional memory, merit-based governance, and ongoing collaboration across generations of researchers.

Evidence Box 10.4. Scientific Sovereignty Is the Foundation of Food Sovereignty

Countries that consistently generate agricultural technologies, train world-class scientists, commercialize innovations, and sustain long-term research investment possess greater capacity to ensure food security, respond to climate shocks, protect natural resources, and compete in global agricultural markets. For Africa, strengthening agricultural research is therefore not simply an investment in science, it is an investment in national resilience, continental integration, economic independence, and the well-being of future generations.

10.7 Final Reflections

The central message of this book is both clear and urgent. Africa's agricultural transformation cannot be accomplished solely through increased production, expanded markets, or the adoption of imported technologies. Achieving sustainable transformation necessitates a robust scientific system that continuously generates knowledge, addresses emerging challenges, informs policy, supports innovation, and creates economic opportunities.

Throughout this review, we have examined the institutional architecture of agricultural research, financing mechanisms, human capacity, research performance, innovation systems, technology dissemination, digital transformation, biotechnology, and strategic foresight. Collectively, these analyses demonstrate that agricultural research is not a peripheral aspect of development policy. Rather, it serves as the knowledge engine underpinning agricultural productivity, food security, environmental sustainability, climate resilience, industrialization, and economic competitiveness.

The concepts introduced in this book, **Agricultural Research Implementation Gap (ARIG)**, **Agricultural Research Investment Paradox (ARIP)**, **Agricultural Research Capacity Gap (ARCG)**, **Agricultural Research Performance Deficit (ARPD)**, **Agricultural Innovation Translation Gap (AITG)**, **Agricultural Research Transformation Index (ARTI)**, and **Agricultural Research Sovereignty (ARS)** offer an integrated framework for understanding the challenges facing African agricultural research and the potential pathways for transformation. These concepts collectively indicate that isolated reforms are inadequate; meaningful progress requires concurrent investment in financing, institutions, human resources, infrastructure, innovation, commercialization, digital transformation, and governance.

The future will belong to African nations that regard research as a strategic national asset rather than a discretionary expense. All successful economies are founded on knowledge, innovation, and sustained investment in science. Agriculture is no exception.

The next phase of African agricultural transformation will be driven not primarily by imported technologies, but by African scientists operating in world-class institutions, supported by domestic investment, connected through continental partnerships, and generating innovations that enhance livelihoods across the continent and contribute to global food systems.

In this envisioned future, Africa will no longer be identified primarily as a consumer of agricultural technologies. Instead, it will be recognized as a producer of scientific knowledge, a developer of transformative innovations, and a global leader in sustainable agricultural development.

The path to Africa's agricultural prosperity begins with Agricultural Research Sovereignty.

Concluding observation

We believe that Agricultural Research Sovereignty (ARS) serves as a fitting capstone for this book because it synthesizes all the major themes addressed: institutional architecture, financing, capacity, innovation, digital transformation, commercialization, regional collaboration, and scientific leadership. This concept also aligns with the long-standing message that **"Africa-led" must ultimately become "Africa-funded"** for the continent to shape its own agricultural future. By concluding on this theme, the book moves beyond diagnosis and presents a coherent vision that policymakers, researchers, and development partners can support in the coming decades.

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FARA
Forum for Agricultural Research in Africa
No 7, Flowers Avenue, New Achimota Mile 7
PMB CT 173, Accra, Ghana
Tel: +233 302 772823 / 302779421
Email: info@faraafrica.org

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