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African Agricultural Transformation: Perspectives from the International Institute of Tropical Agriculture

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ABSTRACT

Agricultural transformation is a broadly recognized approach to African development and is progressing along many fronts. It pursues food and nutritional self-sufficiency, reduces reliance upon costly food imports, and advances Africa within global trade. Improved livelihood among small-scale farming households now garners increased political attention and development investments across Africa now seek to modernize smallholder agriculture in a systematic manner. Commercial seed systems based on recent genetic gains across numerous crops and countries are becoming a realizable priority. Another important target involves transitioning cassava-, maize- and rice-based systems from subsistence to commercial production strategies and adding further value to those commodities. Key drivers include substantial technical and economic empowerment of women and youth; increased advisory, value addition, marketing, and trade services through digital agriculture; and drudgery reduction through greater reliance upon scale-appropriate mechanization. The International Institute of Tropical Agriculture (IITA) and its partners are heavily involved in all areas of this transformational process, primarily through its close working relations with development banks and humanitarian donors, and through partnerships within government programs; and these efforts serve as transformation models for application across Sub-Sahara Africa.

Key Words: Africa, agricultural development, Feed Africa Strategy**,** IITA, Partnerships for Delivery, priority value chains, TAAT Program, technology bundling, youth empowerment

RESUME

La transformation agricole est une approche largement reconnue du développement de l'Afrique et progresse sur de nombreux fronts. Il vise l'autosuffisance alimentaire et nutritionnelle, réduit la dépendance à l'égard des importations coûteuses et fait progresser l'Afrique dans le commerce mondial. L'amélioration des conditions de vie des ménages agricoles fait maintenant l'objet d'une attention politique accrue. Les investissements de développement à travers l'Afrique visent

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désormais à moderniser l'agriculture paysanne de manière systématique. Dans de nombreux pays, les systèmes semenciers commerciaux basés sur les gains génétiques deviennent une priorité réalisable. Un autre objectif important consiste à faire passer les systèmes basés sur le manioc, le maïs et le riz d'une stratégie de production de subsistance à une stratégie de production commerciale et à ajouter de la valeur à ces produits. Les principaux facteurs comprennent l'autonomisation technique et économique accrue des femmes et des jeunes, l'augmentation des services de conseil, de valeur ajoutée, de marketing et de commerce grâce à l'agriculture numérique, et la réduction des corvées grâce à une plus grande dépendance à une mécanisation adaptée à l'échelle. L'Institut International d'Agriculture Tropicale (IITA) et ses partenaires sont fortement impliqués dans tous les domaines de ce processus de transformation, principalement grâce à ses relations de travail étroites avec les banques de développement et les donateurs humanitaires et à travers des partenariats au sein des programmes gouvernementaux, et ces efforts servent de modèles de transformation à appliquer à l'ensemble de l'Afrique subsaharienne.

Mots clés: Afrique, développement agricole, Stratégie Nourrir l'Afrique**,** Institut international d'agriculture tropicale, Partenariats pour la livraison chaînes de valeur prioritaires, regroupement de technologies, autonomisation des jeunes

INTRODUCTION

There is growing recognition that agricultural transformation is both required and actively progressing across Africa. This process serves as a mechanism to achieve food and nutritional self-sufficiency, improve the standard of living of millions of people across the continent, and provide greater and more equitable economic growth. As seen in Asia during the Green Revolution, agriculture has the potential to be a driving force for economic development. Africa has achieved unprecedented economic growth over the past quarter century, often exceeding proportional gains by more developed countries, and this advance has renewed hopes for the continent to fulfill its prospects as a driving force of global agricultural growth (Mukasa *et al*., 2017). Despite these gains, much yet remains to be accomplished in terms of poverty reduction and food and nutritional security (Badiane *et al*., 2021).

The need for further agricultural transformation in Africa is driven by the inability of many countries to produce sufficient food for their people, leading to the massive importation of staple commodities. Technological advancements, such as digital agriculture, innovative farming techniques, and competencies around their usage, are crucial in increasing productivity and resilience among smallholders (Asem-Hiablie *et al*., 2023). However, these innovations must be carefully tailored to the specific needs and scale of Africa's diverse agricultural contexts. Beyond production, this transformation focuses on food systems and commodity value chains that can improve diets and diversify economic opportunities in farming and agro-processing (Herrero *et al*., 2021). Box 1 provides further insights into this transformation progress.

The importance of agricultural transformation now drives the agendas of international finance institutions (IFIs) (AFDB 2016), large and small donor organizations, and a host of agricultural research and development agencies, including the reorganization of the CGIAR. Accelerated agricultural transformation requires not only garnering political will but also aligning policies toward small-scale producers and processors. Oyelaran-Oyeyinka (2020) argues that strong governance and institutional reforms are critical in addressing the historical inequities that marginalize smallholder farmers. Unlike past efforts to revitalize African agriculture, this current transformational phase has gathered sizable political will and initiated additional rounds of policy re-evaluation and reform. The active participation of senior statesmen, members of African governments, and regional organizations in recent landmark events highlights this turning point toward agricultural transformation (Woomer *et al*., 2024a). This paper seeks to provide insight into the

phenomenon of agricultural transformation and to describe how the International Institute of Tropical Agriculture and its partners contribute to its attainment.

INVESTMENTS BY INTERNATIONAL FINANCE INSTITUTIONS AND REGIONAL ORGANIZATIONS

To a large extent, the means of controlling the form and pace of agricultural transformation resides with the developmental investments of IFIs. These institutions offer low-interest loans and grants to developing countries, including provisions intended to modernize agricultural practices and commodity value chains. Less focus is now placed on export commodities shipped in bulk to developed countries, and more attention has shifted to food production and the conditions necessary to increase smallholder productivity and prosperity. These key commodities enhance food security and nutrition and are pivotal in driving rural development at increasingly localized levels. These International Finance Institutions' key role in supporting agricultural transformation is highlighted through their organizing and leadership within a series of high-level regional events and developing special programs in response to changing world economic and climate conditions (Figure 1). Key institutions include the World Bank Group, the African Development Bank, the International Fund for Agricultural Development, the U.S Agency for International Development, the Bill and Melinda Gates Foundation, and the Islamic Development Bank; each with their separate approaches, focus countries and priorities, but in many cases working together as never before.

The commitment to agricultural transformation is illustrated through the African Development Bank, its Feed Africa Strategy (African Development Bank 2016), and outcomes of the Dakar 2 Summit (Akinbamijo, 2023). The Summit increased investment commitments across the continent by assembling 34 Heads of State and government ministers and highlighting the means to achieve country-specific transformation goals. Following the Dakar 2 Summit, eight African countries established Presidential Councils to lead their respective Country Food and Agriculture Delivery Compacts. These Councils operate in Burundi, Cameroon, the Central African Republic, the Democratic Republic of Congo, Nigeria, Sierra Leone, Tanzania, and Zambia. Details on five of these countries are provided in Box 2. Another 12 countries are in the process of doing so. The African Agricultural Leadership Institute, through its support of an AfDB Special Envoy, played an instrumental role in establishing these Presidential Councils (AALI 2023). As a result, AfDB is approving $2.5 billion in 2024 to support these national Compacts, with total financing expected to exceed $10 billion in the near future. A chronology further describing the process of agricultural transformation in Africa is shown in Figure 1.

THE CRITICAL ROLES OF THE PRIVATE SECTOR AND CREATIVE ENTREPRENEURSHIP

Agricultural transformation requires widespread investment by the private sector into the manufacture and distribution of modernizing production inputs and equipment. Much effort has gone into the participation of international and local seed companies and fertilizer manufacturers in regional agricultural transformation programs. More localized blending of fertilizers that are better suited to target crops and soil conditions is a way to increase their use efficiency (Jayne and Sanchez, 2021). Efforts are also underway to accelerate the exploitation of Africa's agro-minerals, particularly lime and rock phosphate, and to further promote Integrated Soil Fertility Management (Sanginga and Woomer, 2009). Private sector opportunities extend to local levels through the operations of agro-dealers and the creation of new and more effectively offered farm services, many of them reliant upon greater farm mechanization (Diao *et al*., 2016; TAAT Clearinghouse 2022) and digitized agriculture (Ayim *et al*., 2022).

Seed systems development is widely regarded as the key starting point of agricultural

Box 1. African agricultural transformation: Some insights into progress.

Importance of rural infrastructure. Establishing an enabling investment climate and providing rural public goods are essential for agricultural development. Addressing market failures that limit access to inputs and financial services is crucial. Smallholders must be continuously integrated into commodity value chains.

Role of small- and medium-scale farmers: Smallholder farmers are central to poverty reduction and economic growth as a workforce. Their productivity remains low, necessitating investments in modern agricultural technologies, skills improvement, and infrastructure. Medium-scale, market-oriented farms increasingly contribute to agricultural output.

Digital agriculture and technical innovation. An assortment of digital services is gaining momentum, with initiatives focused on market information, advisory support, and capacity building. These innovations alter the scope of agricultural extension services.

Socio-technical bundling. Technologies are available to address most agricultural constraints, but their availability and adoption are limiting. Holistic approaches integrating technical innovation with social, economic, and policy dimensions are needed.

Government commitment and policy. Government leadership, effective policies, and strong institutions are crucial for accelerating African agricultural growth. Regional programs and public investments are becoming increasingly successful at meeting development targets. Policies must safeguard land tenure, promote modern agricultural inputs, and ensure market access.

communities in many African countries, and partly because of its potential to nurture public-private partnerships. Seed systems are crucial for linking innovations with farmers by managing the entire value chain of seed development, from germplasm multiplication and conservation to distribution and adoption. These systems ensure timely access to improved varieties and accompanying agronomic practices that enhance productivity, resilience, and food security. While seed roadmaps provide strategic frameworks for investing in seed systems, functional seed systems bring these plans to life, translating research into practical solutions for small-scale farmers. Strengthening these systems is vital for bridging the gap between research and farmers' needs, promoting the adoption of improved varieties, and addressing climate security.

Creative entrepreneurship represents a strategic development intervention to accelerate private sector contributions toward agricultural transformation (Gopal, 2020). Recent university graduates possess the necessary professional capabilities to identify market opportunities and direct their energy, talent, and passion toward entrepreneurial success. Nurturing this process involves business training, peer-to-peer mentorship, and better access to financing through increased creditworthiness. Several new agribusiness models have emerged that are particularly those that involve digital agriculture, contracted service provision and government in creating a conducive agribusiness environment through policies and infrastructure development is also crucial in fostering the growth of creative entrepreneurship. Engaging youth in agriculture can have far-reaching benefits, including addressing the issues of food production, job creation, and economic diversification (Addo, 2018; Laban *et al.*, 2021; Sumberg and Okali, 2013).

AGRICULTURAL PROBLEM-SOLVING THROUGH TECHNOLOGY BUNDLING

Innovation in crop and land management is required because agricultural producers need help to solve the many problems they face with the technologies currently available to them. This innovation assists farming communities to cope with new and changing conditions and to meet the demands of rapidly evolving food systems in ways that produce more crops and livestock, raise their incomes, and improve their diets and health. Improved seed systems must be accompanied by a menu of proven food production technologies bundled into "technology toolkits" (Woomer *et al.*, 2021; Woomer *et al.*, 2023b). These technologies include reliable and more affordable production inputs, soil fertility and pest management strategies, harvest and post-harvest management, and increased mechanization to reduce drudgery. These toolkits embed proven research-to-delivery programs intended to bring positive outcomes for farmers.

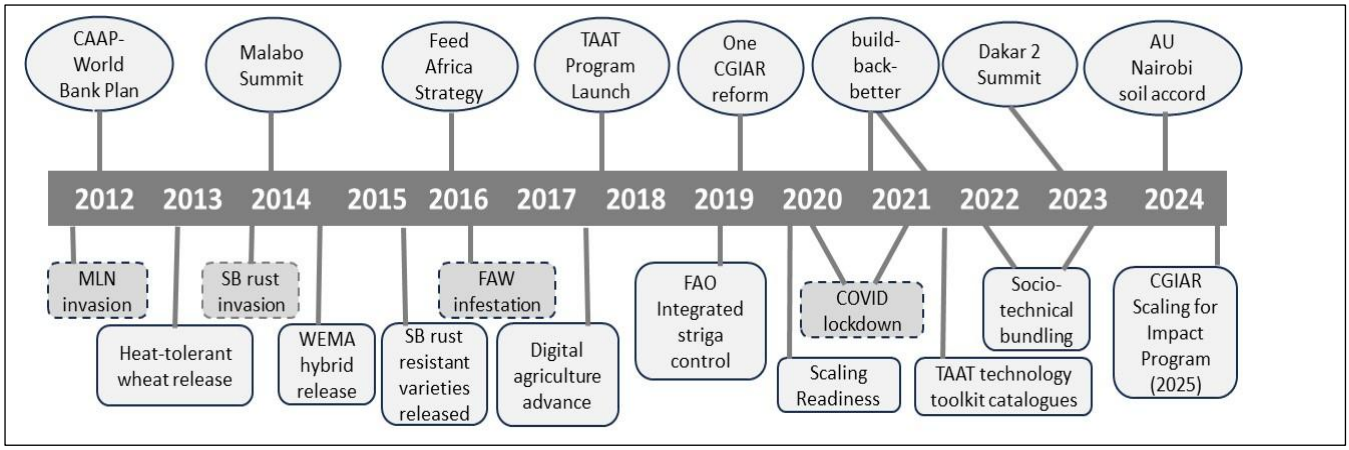

Figure 1. A selected chronology leading to the need and recognition of agricultural transformation as described in this paper; Institutional factors appear above, and crises and responses appear below the timeline. Note that many important technical breakthroughs, including works cited in this paper, are omitted for lack of space.

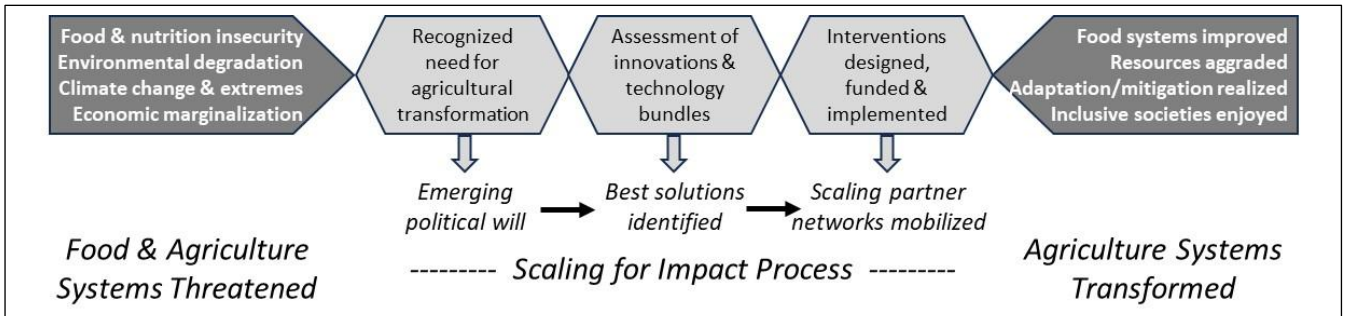

Figure 2. The process of technology scaling within agricultural transformation requires political will, packaging the best solutions and the mobilizing an array of scaling partners.

The introduction of these proven technology toolkits is then "taken to scale" through outreach campaigns, and their impacts are measured (Figure 2). An additional facet of technology bundling is that it allows farmers to access data, monitor soil health and access market intelligence. At the same time, widespread digital applications are changing approaches to field diagnostics and agricultural extension. These technologies often represent Regional Public Goods that offer recognizable benefits and the opportunity for the private sector to develop new and more potent commercial production inputs and equipment around them. Elements of these toolkits are presented for different food commodities later in this paper.

A detailed review of agronomic, digital, genetic, institutional, and mechanical innovations led Barrett *et al*. (2020) to conclude that existing and imminent technical knowledge is less limiting to the progress of African food systems than the constraints posed by a complex array of socio-political factors. This situation is best addressed by coupling technical advances with economic and policy changes to form"socio-technical innovation bundles". Creation of these bundles requires multi-party cooperation across the developmental, financial, public, and private sectors to accelerate their acceptance, diffusion, and scaling. Alternatively, to harness the potential of proven technologies, a full complement of stakeholders must engage in constructive

dialogue on how best to activate them under various socio-economic and agro-ecological conditions. However, this complexity may have been overstated as a fairly standard suite of technologies, consisting of improved crop varieties, judicious use of fertilizers and timely pest-and-disease response, are able to solve many crop production bottlenecks (Jayne and Sanchez, 2021; Woomer *et al*., 2024a).

The process of scaling for impact is summarized in Box 2.

Next, this paper examines selected commodities and cropping systems well positioned to benefit from transformative agricultural programs, with special attention paid to rice, cassava, wheat and maize, and reference made to solutions in the Sahel and Southern Africa.

African self-sufficiency in rice production. Rice consumption in sub-Saharan Africa was approximately 34 million metric tons (MT) in 2020, with imports providing 16 Mt and consumer demand growing at 6% per year. With the threat of mounting importation costs, increasing domestic production has become a top priority for food and economic security in Africa. The African rice sector can become an engine for economic growth across the continent, eliminating extreme poverty and food insecurity in Africa and contributing to employment opportunities. Demand for rice in Africa is growing due to three main factors: African population growth, increased per capita consumption, and a shifting preference toward 'premium' rice among urbanites. Increased rice production and quality processing is readily addressed across Africa through an increasingly-available suite of proven technologies for both irrigated and upland systems (TAAT Clearinghouse, 2021a).

Box 2. From a Dakar 2 idea to the transformative national Food and Agriculture Delivery Compacts recently established in five countries.

Democratic Republic of Congo (DRC). Following the Dakar 2 Summit, DRC established the Presidential Advisory Council for the National Agriculture and Food Pact (Conseil Consultatif Presidential du Pacte National pour l'Alimentation et l'Agriculture (CCP-PNAA)) in August 2023 through a decree by President Félix Antoine Tshisekedi Tshilombo. Agricultural projects in place are financed by the African Development Bank, the International Fund for Agricultural Development, and the World Bank, totaling nearly US $1.5 billion. The Compact's first project, the Agricultural Transformation Agenda, promotes technologies and outreach actions that improve the maize, soybean, and cassava value chains in collaboration with the African Agricultural Leadership Institute and IITA.

Federal Republic of Nigeria. The Presidential Delivery Council for the Nigeria Food and Delivery Compact was established by Vice President HE Kashim Shettima. The Minister of State for Agriculture and Food Security liaises with AfDB regarding ongoing activities and planned investment in wheat, rice, maize, and cassava value chains. One of these projects, The National Growth Scheme Agro-Pocket Project, advances wheat production, and its early success in Jigawa State is being replicated in 14 additional states to reduce costly wheat imports (costing over US $3 billion in 2022).

Republic of Burundi. Burundi's Food and Agriculture Delivery Compact is supported through the Burundi Rwanda Integrated and Development Project. It allows the Ministry of Agriculture to respond to the Dakar 2 Feed Africa Summit in ways that achieve food sovereignty and promote gender equality, financial inclusion, youth empowerment, climate change resilience, and regional integration. Progress is made across the rice, maize, and soybean value chains. Burundi has succeeded in mobilizing substantial resources from the African Development Bank and IFAD to finance the implementation of its Compact (about US $140 million).

The Republic of Cameroon. The Presidential Advisory Council for the National Pact for Food and Agriculture was established by the Prime Minister's Office and the Ministers of Agriculture, Fisheries, and Animal Industries. Its priority is the implementation of the Plaine Centrale Agro Parc Project, supported through a $250 million loan from AfDB. Operations support high-potential agricultural value chains, including palm oil, rice, maize, pineapple, and livestock, and greater private sector and youth involvement.

Republic of Zambia. The Government of Zambia established its Presidential Food and Agriculture Delivery Unit during a commissioning event in April 2024 led by the H.E. Mr. Hakainde Hichilema, AfDB Special Envoy, H.E. Former President of Nigeria Chief Olusegun Obasanjo, and IITA senior staff. Its priorities are insufficient maize and cassava production, agricultural diversification, and processing technologies. Zambia experienced a severe drought in 2024. A bilateral agriculture project involving Zambia and DRC is under development, initiated by President Hichilema, and seeks support from Zambia and DRC to develop stronger common value chains for drought-tolerant crops.

Cassava agro-industry is a widespread developmental goal. Cassava originates from the New World but is well suited to African agricultural conditions, particularly in the humid to sub-humid zones. Africa produced about 175 million tons of cassava in 2020, worth about $7 billion, with the ready potential to double this production. In the past, cassava was too widely viewed as a subsistence crop and food for the poor, when in reality, it has enormous agro-industrial potential. One of these applications is processing into flour, which is useful in baking and other food manufacturing purposes. The most immediate application of cassava flour is its partial substitution in bread and other baked products, reducing demand for imported wheat. However, industrial-scale food processors must make procedural adjustments due the unique chemical properties of cassava flour. Much attention has shifted to the technical advances in cassava production and opportunities for fuller development of cassava as an agro-industrial crop. This trend is intended to provide technical bundles (TAAT Clearinghouse, 2021b) that significantly increase cassava productivity and result in production surpluses, propelling African cassava into world markets as a wide variety of products.

Reduced dependence upon wheat imports. Wheat is an imported commodity in all African countries, and its consumption has steadily increased due to growing population, rapid urbanization, and changing food preferences. Africa is now the world's largest wheat importer, with over 55 MT per year costing about $30 billion and representing a third of the continent's total food imports. Wheat is grown on approximately 10 million ha in Africa, producing around 24 MT yr^{-1}, but recent advances in the crop's heat tolerance and disease resistance suggest that its potential is much greater (TAAT Clearinghouse 2021c). Potential wheat production is no longer limited to the African highlands but extends into upland savannas, where wheat may be grown in rotation with maize and food legumes. There is also the possibility of growing irrigated wheat in the Sahel during its cooler season. Examples from Sudan and Zimbabwe capture improvements in wheat production. The wheat producing area in Sudan rose from 201,000 ha in 2018 to 315,500 ha in 2020, raising production to 1.15 million tonnes. Wheat yields increased from 2.1 to 3.8 t ha^{-1}, emphasizing the importance of irrigated production and other improved management practices. In Zimbabwe, production extended to over 90,000 ha, with plans to increase coverage to 120,000 ha during 2024. This will lead to about 624,000 tons of wheat worth over US $290 million and provide an additional 37 kg per capita. These examples must be replicated elsewhere, with similar successes underway in Ethiopia, Nigeria, and Zambia.

The savanna zone is Africa's next breadbasket. As the moist savannas and dry woodlands of Central, East, Southern, and West Africa are sustainably converted into managed landscapes, they can serve as the grain "breadbasket" of the Continent, and produce food surpluses for export. Morris *et al.* (2021) suggest that this zone contains about 400 million hectares of potentially arable land. In this case, the savanna zone includes the West African Guinea Savanna to the south of the Sahel, the moist savannas of East and the Horn of Africa, and the dryland forests of Southern Africa to the southern Congo Basin (Ker, 1997). Converting these lands to commercial agriculture requires that cereal seed systems be established, soil fertility management products become more available (Jayne and Sanchez, 2021; Woomer *et al.*, 2024b), water resources be developed, and counterproductive practices and policies are corrected. Interventions are built around four interrelated value chains: maize, soybean, dairy, and poultry, and their related processing activities. Numerous scalable agricultural technologies are available, and so are strong networks of potential partners (Adesina, 2019). At the same time, many households in the savanna zone are impoverished, and improvement in their livelihood must not be overlooked in the rush to large-scale industrial farming.

Climate-smart adaptation across the Sahel. Africa's Semi-arid Zone occupies 5.5 million km^2 and supports a population of 109 million. These lands are highly subject to severe drought and extreme weather associated with climate change, affecting both crops and livestock (Sissoko *et al.*, 2011). Water harvesting and

other climate-smart technologies have important applications throughout this zone. Non-cultivated lands are often subject to over-grazing and rangeland degradation, pushing herders to dangerous extremes and making integrated crop-livestock operations especially important. Sahelian soils are primarily sandy with poor water and nutrient retention, and its few inland valleys with better soils and access to water are increasingly subject to frequent flooding (Tambo and Abdoulaye, 2013). This zone is extremely fragile and subject to desertification and catastrophe, but at the same time its people are extremely resilient and prepared for innovative, labor intensive solutions in land management (Doso, 2014). Three key transformational value chains important to this zone are sorghum and millet; accompanying dryland legume production of cowpea, groundnuts, and more recently soybeans; and rearing of goats, sheep, and cattle (Woomer *et al.*, 2023b). Climate-smart technologies may be bundled into toolkits offering solutions by combining improved crop varieties, more effective water conservation practices, and proven approaches for soil fertility and livestock management (Abegunde *et al.*, 2019; Zougmore *et al.*, 2024). Larger-scale impacts are achieved by transitioning from open fields to agroforestry parklands, improved rangeland management, and other climate security actions specifically targeted to semi-arid agro-ecologies.

Diversifying diets in Southern Africa. Southern Africa's agriculture is increasingly focusing on diversifying diets and improving resilience to climate change. In Zimbabwe, farmers are turning to drought-resistant crops sorghum and millet, which are better suited to the country's erratic rainfall patterns compared to maize. These crops require less water, are more adaptable to the region's harsh climates, and are rich in nutrients. This approach is part of a broader strategy to reduce reliance on maize, which is more vulnerable to climate extremes, and to ensure a more resilient agricultural system in the face of unpredictable weather (Tadesse *et al.*, 2018). In neighboring Mozambique**,** potatoes are becoming a key crop for diversifying diets and enhancing food security. Potatoes are well-suited to the country's varied climates and have become increasingly popular due to their adaptability and high market demand. The crop is also contributing to higher income for smallholder farmers and provides a reliable, year-round food source. Alongside crops like potatoes, agroecological practices such as crop rotation with legumes are gaining traction across the region. These practices help improve soil fertility, reduce erosion, and increase long-term productivity. By combining climate-resilient crops with sustainable farming techniques, Southern Africa is working towards creating more diverse, nutritious diets while building a food system that can withstand climate challenges (FAO, 2020; Kusangaya *et al.*, 2018).

DRIVING FORCES OF CONTINUED AGRICULTURAL TRANSFORMATION

Four factors drive expressions of agricultural transformation. Women and young persons are viewed as key clients. Digital agriculture is a tool that redefines how extension campaigns and marketing operations are performed. Small-scale mechanization is crucial to reduce drudgery and redefine perceptions of farming as a career path. Co-creation with stakeholders in the design and implementation of development interventions is seen as an increasingly important element for success. Each of these four drivers are described below and in Box 4.

Women and youth as drivers of agricultural transformation. The economic marginalization of African women and youth is profound, and its consequences are dire. If provided the opportunity, women and youth can establish local businesses involving higher-value and nutritious crops and add value to many agricultural commodities, often to the benefit of local economies. Too many young women and men exist in a prolonged limbo-like state of pre-adulthood where adult independence is not readily available, and the only means of support is through engagement with the informal economy. This state of "living in waithood" creates a condition that reinforces defeatist mindsets, results in enforced idleness, and drives rural youth toward illegal migration and dangerous lifestyles (Honwana, 2019).

Efforts are underway to reverse this trend. Of particular note is the Youth Agripreneur Movement initiated by the International Institute of Tropical Agriculture (Sanginga *et al*., 2023), AFDB's ENABLE Youth Program (Adeyanju *et al*., 2024), International Fund for Agricultural Development's Rural Youth Action Plan (IFAD, 2019), and the Mastercard Foundation's Young Africa Works (Box 3). In this way, the legion of youth significantly contributes to and secures their rightful place within a complex array of rural development opportunities.

Digital agriculture is a critical element. Farming households require more timely and reliable information. Ayim *et al*. (2022) assert that the leading ICT technologies farmers adopt are text-based services targeting mobile phones. Smartphones usher in the next wave of climate-smart advisory, marketing, and financial services (Parlasca *et al*., 2022). Indeed, ICT breakthroughs may not solve the problem of poverty and malnutrition, but they fast-track the progress of solutions available to farmers by providing timely access to necessary information. Electronic messaging holds the potential to revolutionize how agricultural extension systems operate.Youth are particularly adept at using smartphones and serve as entry points for many new applications. Digital applications fall into four broad categories based on their utility: social media groups, online learning platforms, mobile crop and weather advisories, and market intelligence and electronic banking services. These digital tools are driven by cadres of talented, young ICT specialists helping to transform agricultural advisory services (Tsan *et al.*, 2019).

Small-scale mechanization to reduce farm drudgery. African agriculture continues to rely primarily upon human physical labor, and this casts small-scale farming as a life of low-income drudgery. Greater dependence upon mechanization and automation for tillage, weeding, irrigation, and threshing offers an immediate solution, and demand for this equipment is growing (TAAT Clearinghouse 2022). Government-led mechanization efforts appear less effective than private-sector supply models, raising the possibility of public-private partnerships within agricultural development programs (Diao *et al*., 2016). The management of mechanization supply chains and the fabrication, assembly, maintenance, and repair of small-scale equipment must be better provided through secondary, vocational, and university schooling. Where agriculture is successfully commercialized, machinery is becoming available for the first time. However, the profitable introduction of this equipment is not guaranteed because its use requires new skill sets, rigorous maintenance and repair, and safety precautions. At the same time, expanded reliance upon this equipment provides economic opportunity through their commercial distribution and contract service provision period.

Box 3. Innovative Youth in Agriculture in Nigeria

Innovative Youth in Agriculture (I-Youth) was initiated by IITA in 2020 in response to a call by the Mastercard Foundation's Young Africa Works. I-Youth proposed a combined employment- and entrepreneurial-track Theory of Change, supported by a network of public and private sector partners that provided training, business development, job placement, and financial services. Over the following 56 months, I-Youth empowered 64,933 direct and 263,189 indirect beneficiaries through various mechanisms, achieving 160% and 130% of its training targets, respectively. In all, 9,584 new youth-led businesses were created resulting in 40,121 additional jobs. This achievement was not easily won and required flexibility by the Foundation and IITA. The initial requirement of 70% employment-track and 30% entrepreneurial-track youth participation was adjusted toward entrepreneurship as the expected internship and formal employment opportunities were slow to emerge. Six government facilities were renovated to serve as Youth Agribusiness Parks, where pilot enterprises were refined, and large numbers of youth were trained before exiting to start their enterprises. Project success is based on quality technical and business training, the initial provision of key production inputs, affiliation with Youth Agribusiness Parks, linkages to markets through clustering, and access to reasonable finance. The Mastercard Foundation recently contacted IITA to express its willingness to expand this project to other countries, starting with Ghana, Liberia, and Sierra Leone.

Small-scale farming households and communities as participants and beneficiaries. Small-scale farming households are the intended targets and principal beneficiaries of agricultural transformation. Woomer *et al.* (2023a) describe how strengthening the production and processing of key food commodities forms the basis of agricultural development in Africa, with farmers engaged in seven main segments: farm planning > land preparation and crop establishment > field production > harvest > post-harvest handling > marketing > and value addition. Each of these segments contains sub-segments that may be iteratively improved through the promotion and adoption of transformational innovation packages. Crop production packages typically combine input products, labor-saving equipment, and improved land management practices. At first, transformation involves introducing and using a few key technologies that raise yields to a level where year-round food and nutritional security are achieved, as well as modest surpluses marketed for household income (Jayne and Sanchez, 2021). In the fuller context, transformation entails radical changes in farmers' agricultural practices and affiliations to better align them to information sources, input and service providers, commercial markets, and agribusiness (Barnett *et al*., 2020). As rural economies improve, people expect and come to rely upon better education, health and transportation services, and full access to water and electricity, necessitating efficient public spending. Both farmers and local economies respond to opportunities for transformation and its earliest impacts because household benefits are obvious and quickly appreciated.

LEADERSHIP BY IITA'S PARTNERSHIPS FOR DELIVERY

IITA has established a unique approach to scaling research products and consolidating broad-scale collaboration by establishing and operating its Partnership for Delivery Directorate. It simultaneously addresses the need for 1) stronger country engagement in technology delivery and bundling, 2) attracting private sector interests and investment to proven research products from the CGIAR system, and 3) supporting youth and young women as key partners in the modernization of agriculture and the diversification of agribusiness (Thiong'o, 2019). Each of these components has demonstrated success in scaling for impact, ensuring that the reach of proven technologies significantly increased across the continent, and that the solutions are linked to the more significant investments of development agencies.

Box 4. Technologies for African Agricultural Transformation

The Technologies for African Agricultural Transformation (TAAT) is a key flagship program of the African Development Bank's Feed Africa strategy (AfDB, 2016), serving as a significant, continent-wide initiative designed to boost agricultural productivity by rapidly delivering proven technologies to millions of farmers. The developmental objective of TAAT is to rapidly expand smallholder farmers' access to high-yielding agricultural technologies that improve their food production, assure food security, and raise rural incomes. IITA coordinates TAAT and aims to double crop, livestock, and fish productivity by expanding access to productivity-increasing technologies to more than 40 million smallholder farmers across Africa by 2025. It seeks to generate an additional 120 million metric tons of food annually. TAAT operates as a consortium of partner's intent on eliminating extreme poverty, ending hunger and malnutrition, turning Africa into a net food exporter, and positioning Africa at the top of agricultural value chains. TAAT partners with the CGIAR and other Advanced Agricultural Research Institutes to provide proven technologies to National Agricultural Research and Extension Systems, Ministries of Agriculture, the private sector, farmers' cooperatives, and charitable organizations involved in agricultural development in order to deploy agricultural innovations at scale. The commodities of greatest interest to TAAT are rice, wheat, maize, sorghum, millet, beans, cassava, sweet potatoes, fish, small livestock, vegetables, and soybeans. TAAT is currently compiling a comprehensive catalog of technologies for agricultural planners and the private sector. TAAT has proven particularly effective in assisting international finance institutions in developing potent agricultural development programs for their sovereign country loans. More information on TAAT is available from its website: https://taat-africa.org/about-us/ .

With its very clear mandate, the CGIAR ensures that the technologies it develops, such as drought-resistant crops and sustainable farming practices, directly address the challenges farmers face. Most recently, the CGIAR initiated the Scaling for Impact Program designed to assist in mainstreaming proven technologies and formulating them into widely-appreciated development packages.

Country engagement is best conducted in partnership with international development banks and large humanitarian organizations. An example of this approach is found in the Technologies for African Agricultural Transformation (TAAT) Program and its close initial relationship with the Feed Africa Strategy of the African Development Bank and the Bill and Melinda Gates Foundation (Woomer *et al.*, 2021) (Box 4). Another example of fruitful country engagement is illustrated through the rapid achievements of the DR Congo Agricultural Transformation Agenda (Woomer *et al.*, 2024b) (Box 5). Yet another example is the recently launched West African Fertilizer Innovation Hub, which has secured funding from an international fertilizer company (OCP Africa) and the World Bank. This hub is a collaborative effort led by the Economic Community of West African States headquartered at IITA in Ibadan, Nigeria, with a supporting facility at the University Mohammed VI Polytechnic (UM6P) in Morocco. This approach represents a practical and integrated response to the concerns of the Fertilizer and Soil Health Initiative recently initiated by the Africa Union.

Another form of needed scaling involves the accelerated commercialization of CGIAR research products. In the past, research product outreach to the private sector was too often an ad hoc effort conducted toward the end of otherwise successful research projects. This situation too often resulted in little or no scaling impacts from proven new production inputs and management practices. This situation has changed at IITA through the advent of the Business Incubation Platform (BIP). Once a potential agricultural product undergoes successful testing and preliminary economic analysis within a research project, scientists inform the BIP of their accomplishment and invite the BIP to assess, pilot, and market emergent research products as commercial opportunities. New products passed to the private sector for further investment through this mechanism include improved crop varieties, nitrogen-fixing inoculants (Box 6), and strategies allowing for the biocontrol of mycotoxins (IITA-BIP 2024).

The social and economic marginalization of youth resulting from insufficient opportunity for decent employment in rural and urban areas represents a considerable threat to future civil stability. The IITA Agripreneur Movement identified which agribusiness models are most attractive to youth and how best to fashion their business interests and creditworthiness (Sanginga *et al.*, 2023), and the ENABLE-TAAT Compact extended this model and effectively incorporated it within several national development plans (Adeyanju *et al.*, 2024).

Box 5. DR Congo Agricultural Transformation Agenda (DRC-ATA)

This Agenda for the Transformation of Agriculture in the Democratic Republic of Congo is fulfilling a Presidential promise to modernize the country's agriculture. The Government appointed IITA to lead this Agenda in early 2022. It increases agricultural production through greater use of improved crop varieties and building solid seed systems in close collaboration with the national agriculture research system, regulatory bodies, and in partnership with some budding private sector operators. Starting with the 2022-2023 growing season, this program established 1,518 ha into modernized crop production, including 547 ha of maize, 864 ha of cassava, and 81 ha of soybean. Most of this area is located on under-performing state farms (83%) but with increasing attention on establishing vibrant out-grower networks. Seed production occurs on an additional 434 ha, including 188 ha of IITA's improved cassava varieties that provided about 38 million cuttings. By 2023, 979 tons of improved maize, soybean, bean, and rice seeds were produced for distribution to national partners. Out grower networks are forming around these facilities and supported with the requisite farm inputs to ensure an adequate and reliable supply of raw materials, access to steady markets, and that food crops are locally processed rather than taken to neighboring countries for value addition and re-importation. The start of the second phase of ATA-DRC will put into practice the successful outreach program developed in the Ruzizi Plain to the other participating provinces. The success of DRC-ATA has recently led to the award of a large ($310 million) sovereign country loan, “Project to Support the Development of Agricultural Value Chains in Support of the Agricultural Transformation Program," designed to support the country's maize and cassava production.

Box 6. NoduMax™: A Soybean Inoculant for Africa

NoduMax™ is a legume inoculant produced and distributed by the IITA Business Incubation Platform in Nigeria. A solid inoculant for soybeans is its main product line. It contains *Bradyrhizobium japonicum* strain USDA 110 variant "Tiny" within a peat carrier material. The broth is produced in 17-liter batches and tested for purity, and individual bags of sterile peat are injected using an automatic pipette under filtered laminar flow. The puncture is sealed, the mixture kneaded immediately by hand, and the inoculant is cured for 14 days under controlled temperature and humidity. After curing, 2% of each batch is tested to ensure that the product contains at least $1x10^9$ live rhizobia and is free from contamination. 100 g of inoculant is packaged with 20 g of Gum Arabic adhesive and an instruction leaflet in three Nigerian languages. English language instructions appear on the outer package. Inoculant is boxed into units of 50, stored in a cool room, and has a proven shelf life of 18 months. Each package of 100 g is suitable for inoculating 10 to 15 kg of seed. The BIP factory has a production capacity of 24 tons per year (240,000 packets). When properly applied to soybean seeds before planting, repeated tests yield increases of 35-40%. The product is primarily marketed in Nigeria but distributed to nine additional countries (Benin, Burkina Faso, DR Congo, Gambia, Ghana, Mozambique, Togo, Zambia and Zimbabwe). Note that inoculants for beans, groundnuts, cowpeas, and a liquid formulation better suited to machine planting are also available through special order.

The I-Youth Project, supported by the Mastercard Foundation in Nigeria, allows for a more widespread application of vocational learning-by-doing (Box 3). DR Congo established a Youth Brigade as part of its Presidential Agricultural Transformation Agenda, and these youth proved adept at organizing and implementing community outreach programs in places where more traditional agricultural extension was weak or "non-existent" (Woomer *et al.*, 2024b). Over the past decade, IITA and its partners established the practical foundations of youth empowerment that now must be more widely incorporated into updated national agricultural development programs.

CONCLUSIONS

Africa has achieved unprecedented economic growth over the past 25 years, but this favorable macroeconomic performance has yet to impact the agricultural sector, an area that employs 65% percent of its workforce. Ironically, GDP growth originating from agriculture is substantially more effective in reducing poverty than growth from non-agricultural sectors, so improved quality of life across Africa necessarily involves agricultural performance. The necessary components to transform African agriculture are in place in terms of modernizing technologies and institutional reforms. The ability to overcome a host of economic and social challenges by supporting inclusive economic growth is now within reach.

Agricultural transformation is already underway in several African countries, and rapid growth in higher value crops and value addition is primarily driven by changing consumer demands in urban areas. At the same time, further innovation in land management and cropping systems is required because we cannot solve the full range of food and climate problems faced by small-scale African farmers through available practices. Technology bundling must be directed toward meeting increased and changing demand for healthier food and assisting African nations and farming communities to cope with a warming world and its more erratic weather conditions. Several policies drive agricultural transformation related to agricultural trade, rural economies, and research and development institutions. Tariffs and their impacts on farm production inputs and commodity outputs can be significant, and in general, the less taxation, the better. These include import tariffs, export taxes, export subsidies, and other safeguard measures. Subsidies that reduce producer costs may also be better managed to stimulate the production of essential commodities.

From a human developmental standpoint, a major goal of agricultural transformation is to produce more crops and livestock so farming households can raise their incomes, allowing members to receive the nutritious diets they deserve. This achievement corrects the world's greatest inequity; that poorer households suffer from worse health, and children from these households are less able to cope with the challenges posed to future generations. In the journey toward agricultural transformation, leadership is crucial in positioning people of vision to drive groundbreaking change, and it is influential leaders who create the supportive environment needed to amplify proven impact

pathways. For now, and into the future, we must work together in our various capacities to ensure that the promise of agricultural transformation made to poor African farming households and small agri-business operators by development specialists, agricultural scientists, and African leaders must be realized!

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest in this paper

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