



CHAPTER 15

Technology Development and Adoption in Chinese Agrifood Systems: Implications for Africa

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Introduction

China's agrifood transformation over the past 75 years offers valuable insights for African countries as they face common challenges, such as climate change, imbalance of nutrition, and global trade vulnerabilities, in their efforts to improve food security. The country's efforts to develop its agricultural sector and ensure national food security can be divided into three stages.

- In the early years after the founding of the People's Republic of China (PRC) in 1949, the primary focus was on increasing grain production under a planned economy system. However, this approach often struggled to meet the population's staple food needs. Economic reforms starting in 1978 expanded agricultural production, particularly through the decollectivization of agriculture and the introduction of the household responsibility system.
- As urbanization progressed and incomes rose, consumers sought greater variety and quality in their diets. Following the PRC's accession to the World Trade Organization in 2001, international market integration led to a significant increase in the supply of meat, eggs, dairy, fruits, and vegetables. At the same time, domestic production expanded, so that by 2012, per capita grain production exceeded the safety line for grain security, marking a shift from supply shortages to abundance.
- In the 2010s, quality improvement and sustainability became central to agricultural policy. To achieve these aims, technological innovation in agriculture was strongly supported, while policies were implemented to reduce fertilizer and pesticide use, promote green production practices, and elevate food safety standards. Since 2020, agrifood system development efforts have aimed to encourage a shift toward balanced nutrition and a sustainable environment.

The transformation of agrifood systems in the PRC has been based on the coordination of institutional reforms, technological innovations, and strategic adaptation. Its agrifood systems now balance quantitative food security, quality improvement, food safety, and environmental protection. China's experience of achieving universal nutritional improvement with limited resources provides

important insights for African countries facing similar challenges in food security and dietary transformation.

Technology in the transformation of China's food systems

Technology has played a pivotal role in transforming China's agrifood systems across three broad areas, enabling China to feed nearly 20 percent of the global population with only 9 percent of the world's arable land.

- **Enhanced agricultural productivity and resource use efficiency.** Precision agriculture technologies, such as remote sensing and smart irrigation systems, enable farmers to manage land more scientifically. The implementation of fertilizer and pesticide reduction policies relies on slow-release fertilizers and intelligent pest warning systems. Breakthroughs in biotechnology, such as the development of stress-resistant crops, have improved resilience to climate change while maintaining high yields. Clean energy technologies, such as agricultural photovoltaics, combine agricultural production with energy generation, reducing dependence on traditional energy sources. Circular agricultural models utilize waste resources in agricultural production to minimize environmental impact. Facility agriculture models that rely on environmental control technologies, such as vertical farming and microbial protein synthesis, are expanding to reduce the environmental footprint of agricultural production while lowering greenhouse gas emissions.
- **Ensuring food safety, nutritional health, and the resilience and inclusivity of food systems.** Innovations in food processing, such as nutrient fortification and low-temperature sterilization, have improved the quality and safety of agricultural products. Blockchain traceability technologies have enhanced supply chain transparency. Agricultural big data platforms and disaster warning systems have enhanced the ability of agricultural value chains to withstand extreme weather events and market fluctuations. The development of e-commerce platforms and cold-chain logistics better connects smallholder farmers to markets, fostering common prosperity.

- **Policy coordination and international cooperation.** Technological research and the transfer of the innovations developed to other potential users help build a global food cooperation network. For instance, China's hybrid rice technology has helped countries globally improve their food security, while cross-border sharing of digital agricultural technologies has optimized resource allocations. To promote innovation in agriculture, the PRC has established science and technology research incentive mechanisms to accelerate the commercialization of green technologies.

Through targeted support and organizational innovation, technological breakthroughs and policy implementation have mutually reinforced each other, providing a solid foundation for the development of high-quality agrifood systems.

Sharing China's experiences with Africa

China's experience in agrifood system transformation offers valuable lessons for African countries as they develop and implement their own transformation strategies. Through multiple channels, China has provided technological and knowledge-based support to Africa and will continue to deepen its collaboration with Africa.

One important avenue for the PRC to enhance the productive capacity of African agrifood systems is through technology transfer and infrastructure cooperation. This technology-driven cooperation bolsters Africa's food self-sufficiency through engaging smallholders to enhance systemic inclusivity and improve their resilience. China has promoted hybrid rice technology in Africa, established agricultural demonstration centers, and improved irrigation systems and logistics facilities. China is committed to providing RMB 1 billion (US\$ 140 million) in emergency food aid, constructing 100,000 mu (6,500 ha) of agricultural demonstrations, and dispatching 500 agricultural experts to support agrifood system development in Africa in the coming years. These resources will be provided under a synergistic development model of "nutrition-agrifood-environment," introducing green technologies and resource-intensive practices to Africa that simultaneously increase food production growth while reducing environmental burdens. Additionally, to help build diversified food systems, the PRC is assisting African countries with vegetable and fruit processing technologies.

Secondly, China seeks to integrate its agrifood systems with those of Africa through policy coordination and institutional innovation. The PRC

is establishing agricultural industrial parks in Africa that integrate production, processing, and logistics across entire value chains. Laboratories at the technology demonstration centers that China is establishing in partnership with African governments facilitate localized seed breeding and mechanization technologies. Capacity-building is part of these initiatives, such as training agricultural technicians and integrating poverty alleviation objectives into agrifood development to strengthen endogenous growth. The China-Africa Digital Technology Cooperation Center has been established. This effort includes 20 digital demonstration projects. These efforts intertwine technological collaboration with improvements in livelihoods. Future cooperative efforts in these domains will seek to strengthen top-level design, integrate food security resilience into planning, coordinate resource allocations through cooperation platforms, and enhance collaboration with NGOs and local communities to resolve structural contradictions in the distribution of resources. Ultimately, the aim is to systemically transition from a pattern of external assistance for development initiatives to self-sustaining development pathways.

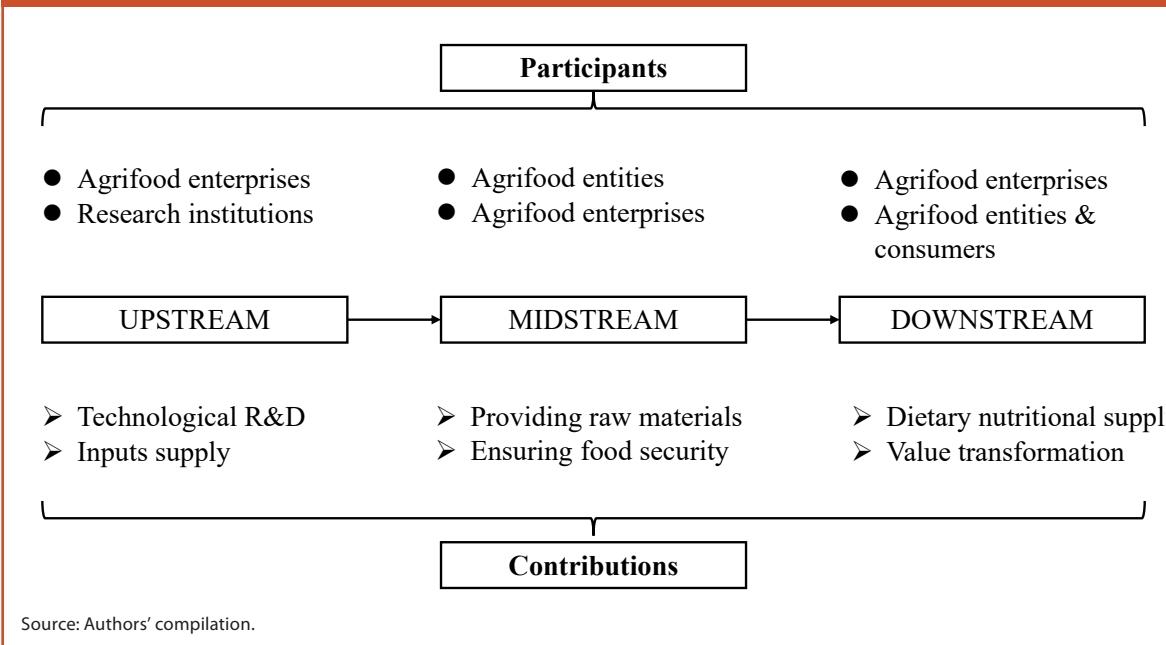
The agrifood transformation of the PRC over the past 75 years offers important lessons for addressing food security and nutritional challenges in African countries. By sharing its experiences in technological innovation, institutional reform, and policy coordination, China can provide insights for Africa's transition toward more resilient, inclusive, and sustainable agrifood systems. Worthy of note is the fact that, given the vast area and complex ecosystems in Africa, a regional screening framework to align Chinese technologies and know-how should be established with dedicated funds and the scaling up of farmer field schools.

Technology for Transforming China's Agrifood Systems

Key participants

In China's agrifood value chains, the primary participants play indispensable roles. These include production entities, such as smallholder family farms and cooperatives, agrifood enterprises of various sizes, and the government. Together, they maintain the operations of China's agrifood systems and promote agricultural modernization and sustainable development in the country.

FIGURE 15.1—KEY PARTICIPANTS AND THEIR CONTRIBUTIONS IN THE AGRIFOOD SYSTEMS



Source: Authors' compilation.

Agrifood value chains can be divided into upstream, midstream, and downstream segments, each with distinct roles for participants (Figure 15.1). The upstream segment pertains to technological research and development and agricultural input supply, which in China are primarily managed by agricultural enterprises and government-affiliated research institutions. Agricultural production entities are primarily responsible for the midstream phase, providing raw materials for downstream processing and distributing agricultural products. In the downstream segment, the processing and distribution of agrifood products are mainly carried out through collaborations between agricultural enterprises and certain agrifood processing entities, serving as a key link in ensuring dietary supply and realizing the value transformation of agricultural products.

The government's support for agrifood systems in the PRC permeates all segments of agrifood value chains. By formulating targeted policies, the government optimizes resource allocation within agrifood systems, adjusting those allocations to meet the interests of value chain participants. Doing so guides

and supports the transformation of agrifood systems across China towards safety, sustainability, and inclusivity. Through rural infrastructure development, the government also enhances agricultural production and agrifood marketing by improving transportation, water supply, electricity, and information networks. Additionally, the government promotes agricultural research and the adoption of new production and processing methods by supporting networks of agricultural research institutions and technology promotion departments that work in collaboration with universities. Finally, the government engages with foreign agricultural researchers to introduce advanced technologies and management practices from abroad into domestic agrifood systems.

The main participants in China's agrifood value chains play distinct yet complementary roles. Smallholder family farms, cooperatives, and agrifood enterprises, including small- and medium-sized ones, provide robust impetus and support for technological innovation, production efficiency, and market responsiveness. Meanwhile, the government establishes a

conducive development environment through policy guidance, infrastructure development, and technological research and development. Through this diversified participatory structure, China's agrifood system has achieved continuous growth and transformation.

Key technologies in agrifood value chains

Inputs

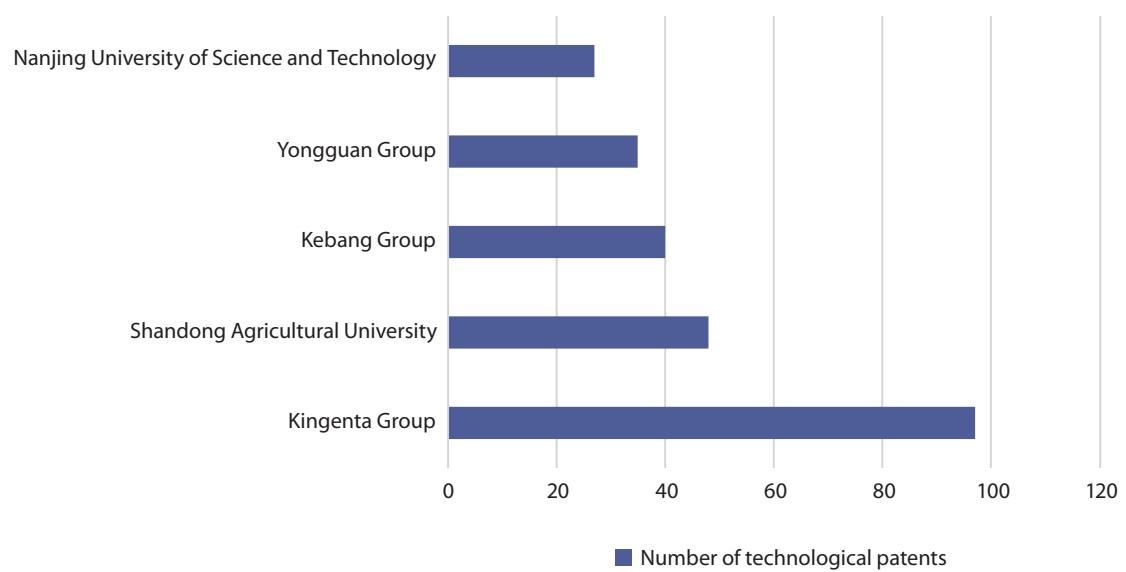
Intelligent Fertilizer. Smart fertilizer technology seeks to optimize fertilizer usage to achieve efficient, economical, and environmentally friendly crop fertilization outcomes. Unlike traditional fertilizers, smart fertilizers automatically adjust the amount of nutrients they release based on the crop's growth requirements, soil composition, and variations in environmental conditions, thereby facilitating precision fertilization. Smart fertilizer systems typically involve controlled,

slow-release fertilizer products, intelligent soil monitoring, and optimized nutrient formulations, which not only enhance fertilizer utilization efficiency but also play a significant role in environmental protection and in addressing sustainability challenges. The utilization rate of nitrogen in fertilizers can increase by up to 30 percent when smart fertilizers are applied. Average yields of rice and maize have increased by 7.6 percent relative to conventional fertilizers and fertilization practices. Furthermore, the controlled release characteristics of smart fertilizers decrease nutrient losses. In addition to being better for the environment, these fertilizers minimize resource waste, enhancing the efficiency of farming.

In 2006, the Chinese government provided RMB 50 million (US\$ 7 million) for the development of controlled-release fertilizers (Gu et al. 2014). Several agricultural enterprises and research institutions are now involved in such research, with many now commercializing their new technologies (Figure 15.2).

Drought-tolerant Seed. This technology involves developing crop seeds adapted to arid, high-temperature environments through a combination of traditional breeding and modern biotechnology, including molecular marker-assisted selection and gene editing. These seeds can maintain higher growth potential and yield under water-limited conditions to assist farmers in addressing uncertainties in agricultural production brought about by climate change, thereby protecting their interests and ensuring national food security. In the northern arid regions of China, the large-scale promotion of drought-tolerant wheat and maize varieties has resulted in relatively stable yield levels over time, even in drought years. For example, the drought-tolerant early maize variety developed by the Longping High-Tech company achieved average yields that were 20 percent higher than those of conventional maize varieties, while drought-tolerant wheat varieties provided yields 15 percent higher than conventional wheat varieties. Moreover, the use of drought-tolerant varieties effectively addresses some of the issues related to water resource scarcity and

FIGURE 15.2—PATENT HOLDERS OF INTELLIGENT FERTILIZER TECHNOLOGY IN CHINA, PATENTS HELD, BY LEADING AGRICULTURAL ENTERPRISES OR RESEARCH INSTITUTIONS, 2024



Source: Chen and Zhao (2024).

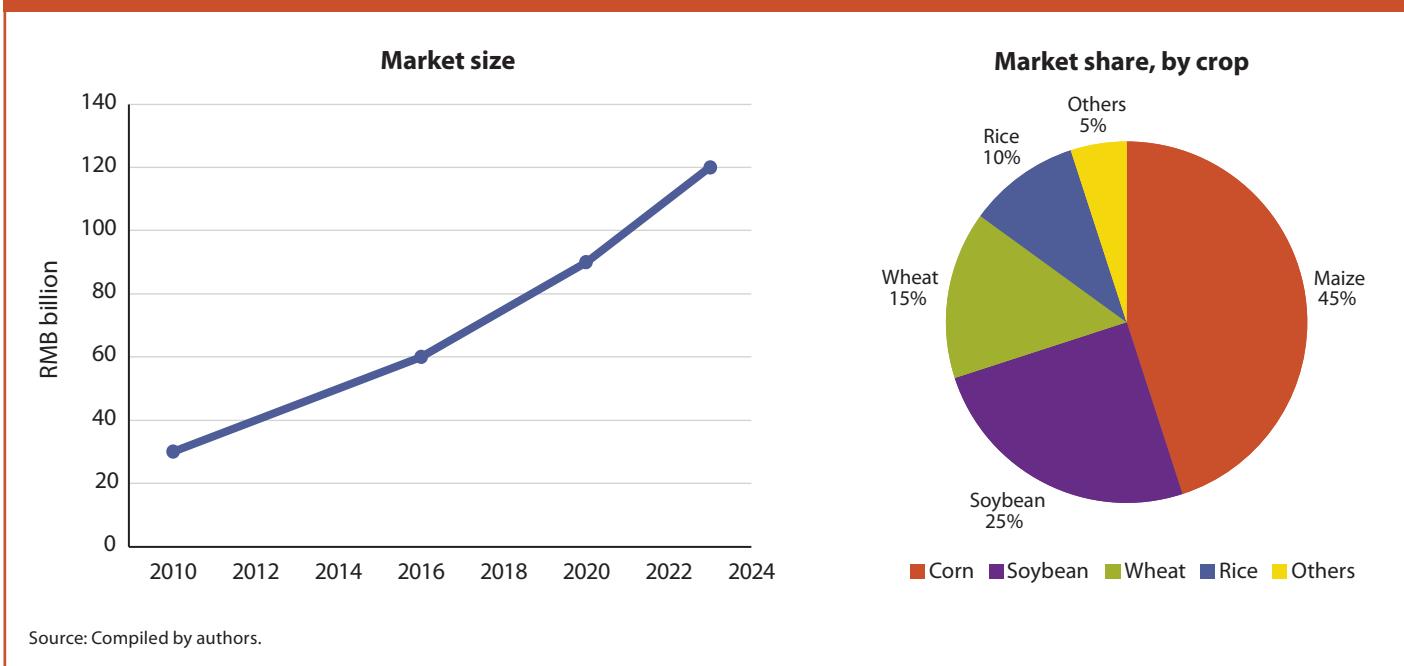
reduces associated environmental problems, such as soil salinization caused by over-irrigation.

The Ministry of Agriculture and various local agricultural departments have provided policy support for the research and application of drought-tolerant seed technology. In 2023, the Ministry allocated RMB 1 billion (US\$ 140 million) for research into the technology and its promotion. The market for drought-tolerant seed has been expanding annually, reaching RMB 12 billion in 2023 (Figure 15.3). Maize occupies 45 percent of the market share. Agricultural enterprises are the main investors in the research and development of drought-tolerant seeds.

Production

Biological and Ecological Integrated Pest Management (IPM). IPM is a method that utilizes ecological principles and practices, biological control, and agricultural management techniques, together with chemical control, to reduce the

FIGURE 15.3—MARKET OF DROUGHT-TOLERANT SEED IN CHINA—GROWTH IN MARKET SIZE, 2010 TO 2023, AND SHARE, 2023, BY CROP



frequency and severity of pest and disease occurrences in crops. This approach emphasizes the protection of the environment and biodiversity while ensuring the sustainability and economic viability of agricultural production. The promotion of IPM in China has significantly reduced the use of chemical pesticides and enhanced both crop yield and quality. Government and social organizations have promoted the widespread adoption of IPM through farmer training and technology dissemination, establishing an effective mechanism for technology transfer.

IPM has become a key area for national biotechnology development. A comprehensive pest and disease control system for crops is being established, as plant epidemic monitoring and control is now viewed as a

TABLE 15.1—ECONOMIC BENEFIT EVALUATION OF INTEGRATED PEST MANAGEMENT APPLIED TO MAIZE

Variety type	Initial investment, RMB thousand	Production increase, %	Cost reduction, %	Income increase, %	Technology investment payback period, year
Transgenic maize	500	20	15	25	3.0
Insect-resistant maize	300	15	10	20	2.0
Gene-edited maize	400	18	12	22	2.5
Biopesticides	200	10	8	15	2.0

Source: Zhang (2024).

matter of national security. Four laboratories focused on biopesticide development are now operational, including one at South China Agricultural University. In 2022, the number of enterprises in China engaged in biochemical and microbial pesticide manufacturing reached 154, with total output valued at RMB 41.6 billion. Table 15.1 shows the commercial benefits of IPM by type as determined from analysis of data from agricultural technology service centers across China.

Smart Agricultural Technologies. These refer to the use of digital information technologies, such as the Internet of Things (IoT), big data, artificial intelligence (AI), and cloud computing, to establish monitoring and control systems for agricultural production, management, and service provision. Their use aims to enhance the efficiency and sustainability of agricultural production, in particular, but also agrifood processing. Agricultural production efficiency has significantly improved in China through the application of smart agriculture technologies. By leveraging sensors and smart devices, agricultural producers can monitor environmental factors in real time and accurately adjust crop growth conditions. Among the advanced production methods supported by smart agricultural technologies are precision fertilization, precision irrigation, and intelligent monitoring of pests and diseases. Many agricultural research institutions and universities have established technology demonstration bases in rural areas, facilitating local farmers' exposure to these technologies and enhancing their overall technical skills and literacy.

The application scenarios for smart agriculture are expanding, so the market continues to grow. In 2023, China's smart agriculture industry market reached RMB 71 billion (US\$ 10 billion) with an annual growth rate of 9.2 percent. Over the past five years, the demand for agricultural robots in China has grown by 39 percent. The Modern Agriculture Platform model, a suite of digital agricultural tools for both production and marketing established by the private sector firm, Syngenta, continues to expand (Figure 15.4). In 2022, there were 32 financing events in China's smart agriculture sector, with total financing amounts reaching RMB 2.4 billion.

Processing

Byproducts Utilization. New information technology, engineering technology, and biotechnology techniques are being developed and deployed in China to achieve efficient utilization of these byproducts and maximize economic value from the further processing of byproducts generated during agricultural production. These byproducts include those from the processing of grain, fruit, and vegetables, as well as waste from livestock and poultry farming. These technologies not only enhance the value of agricultural products but also help to reduce environmental pollution and achieve sustainable development. The application of agricultural byproduct utilization technology has significantly reduced resource waste in agricultural production in China by enabling the use of materials that were previously often burned or buried in landfills due to a lack of effective utilization pathways. The utilization of agricultural byproducts directly enhances the economic benefits of agriculture. Byproducts such as sweet potato and sugarcane waste can be processed to produce sugar, starch, or directly converted into feed, while cereal straw can be composted and converted into organic fertilizer to improve soil structure, enhance soil fertility, and reduce chemical fertilizer usage.

FIGURE 15.4—MODERN AGRICULTURE PLATFORM USERS IN CHINA, 2022

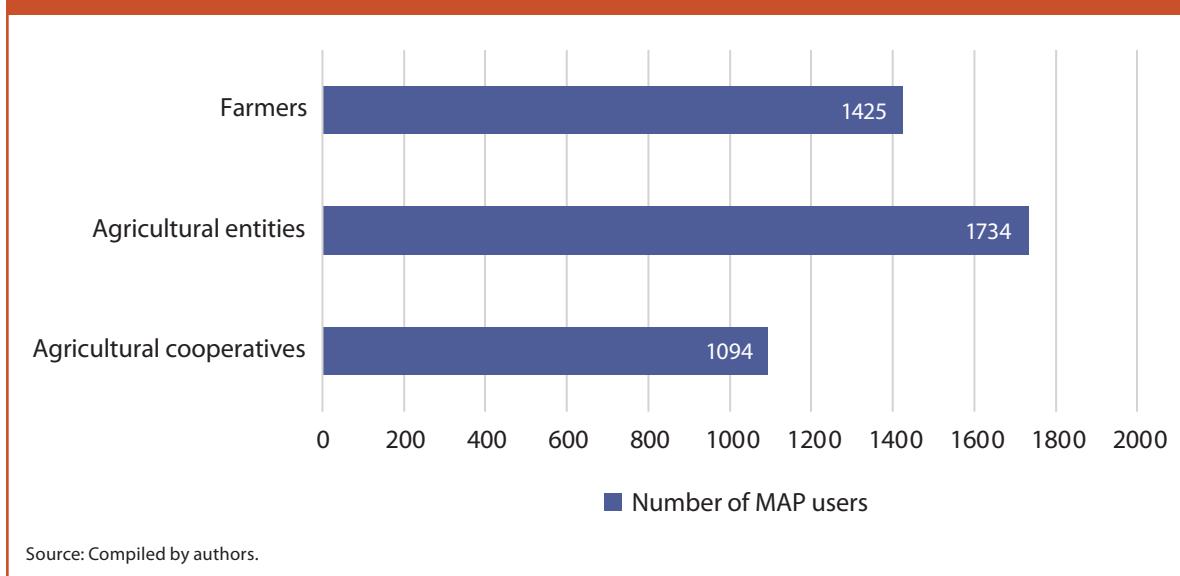


TABLE 15.2—COMPREHENSIVE UTILIZATION OF BYPRODUCTS OF AGRICULTURAL PRODUCTION AND PROCESSING RECOMMENDED BY THE CHINESE MINISTRY OF AGRICULTURE

Byproducts	Utilization technology
Agricultural production	Extracting cellulose and hemicellulose from straw Production of natural paper and humic acid from straw Fermented straw for planting edible mushrooms Production of CO ₂ fertilizers and biomass fuels from straw Waste bacterial packaging and residue
Grain, oil, and potato processing	Producing oil and oleic acid from rice bran Rice husk power generation Organic fertilizer and monosodium glutamate from maize processing byproducts Production of dietary fiber and edible vinegar from sweet potato peel residue Production of cotton protein, gossypol, and other products from cottonseed byproducts
Fruit and vegetable processing	Extracting pectin from apple and citrus peel residue Citrus peel residue processing for tea and sauce Development of seasoning from byproducts of mandarin and freshwater fish processing
Livestock and poultry processing	Using cowhide to produce collagen casing Production of peptides and feather powder from livestock and poultry Organic calcium from the byproducts of poultry eggs
Aquatic product processing	Production of feed and chitin from the byproducts of fish Shrimp processing

Source: Compiled by authors from official documents.

Additionally, the use of biomass energy reduces reliance on traditional fossil fuels and decreases greenhouse gas emissions. China's Ministry of Agriculture is now promoting 18 models for the comprehensive use of agricultural byproducts across five areas: agricultural production; grain, oil, and potato processing; fruit and vegetable processing; livestock and poultry processing; and aquatic product processing (Table 15.2).

Deep Processing Technologies. Deep processing refers to the transformation of primary agricultural products into high-value foods or other products through a series of physical, chemical, and biological methods. These include,

but are not limited to, refrigeration, drying, fermentation, extraction, refining, and packaging. Deep processing not only increases the economic value of agricultural products but also expands their market applications, enhances food safety, and improves nutritional levels. Deep processing of agricultural products not only drives the development of the agrifood value chains but also promotes structural upgrades in local economies.

Agrifood processing is supported and guided by policies of the PRC government. These promote collaborative actions along agrifood value chains, including securing raw materials for agricultural products, building industrial clusters, enhancing technological infrastructure, and expanding new business models. Agricultural enterprises, agricultural parks, and cooperatives are the main participants in this sector. In 2023, agrifood industries, including both edible and non-edible agricultural processing, were projected to achieve approximately RMB 130 trillion (US\$ 18.2 trillion) in revenue.

E-commerce in Agrifood Products. E-commerce for agricultural products involves the use of internet platforms to sell agricultural products directly from producers to consumers. Through online channels, farmers, agricultural cooperatives, and enterprises can rapidly and extensively market their products, facilitating more efficient transactions. Agricultural e-commerce encompasses the use of digital technologies, such as mobile payment systems, social media marketing, other forms of online promotion, big data analysis, and cloud computing, to enhance the commercialization of agricultural products and optimize agrifood product supply chains.

Agricultural e-commerce has significantly expanded market access for farmers and agricultural cooperatives across China. Traditional agricultural sales channels are often constrained by geographic location and information asymmetry. However, e-commerce has broken many of these barriers, enabling farmers to access national and global consumer markets directly. For instance, smallholders in remote areas have utilized e-commerce platforms to sell specialty agricultural products or handicrafts to a much wider range of

consumers, achieving a transition from local to national markets. Agricultural e-commerce platforms also provide consumers with more information, including product origins, nutritional content, and market prices. Numerous e-commerce enterprises and entrepreneurs have emerged in rural areas, energizing those rural economies.

The scale of agricultural e-commerce continues to expand. In 2023, national online retail sales of agricultural products reached RMB 587 billion (US\$ 82 billion), approximately five times the sales of 2014. The government has supported the establishment of almost 1,500 county-level e-commerce public service centers, nearly 3,000 logistics distribution centers, and over 158,000 village-level e-commerce service stations. This has facilitated the flow of industrial products into rural areas and agricultural products into urban markets.

Leading e-commerce giants in China, such as Pinduoduo, have played a pivotal role in this transformation. Pinduoduo has developed the Cloud

Farming Group Purchase system, which aggregates dispersed online demand for agricultural products to deliver them directly from producers to consumers (Figure 15.5). This not only lowers end prices but also increases farmers' incomes (Danyun 2024).

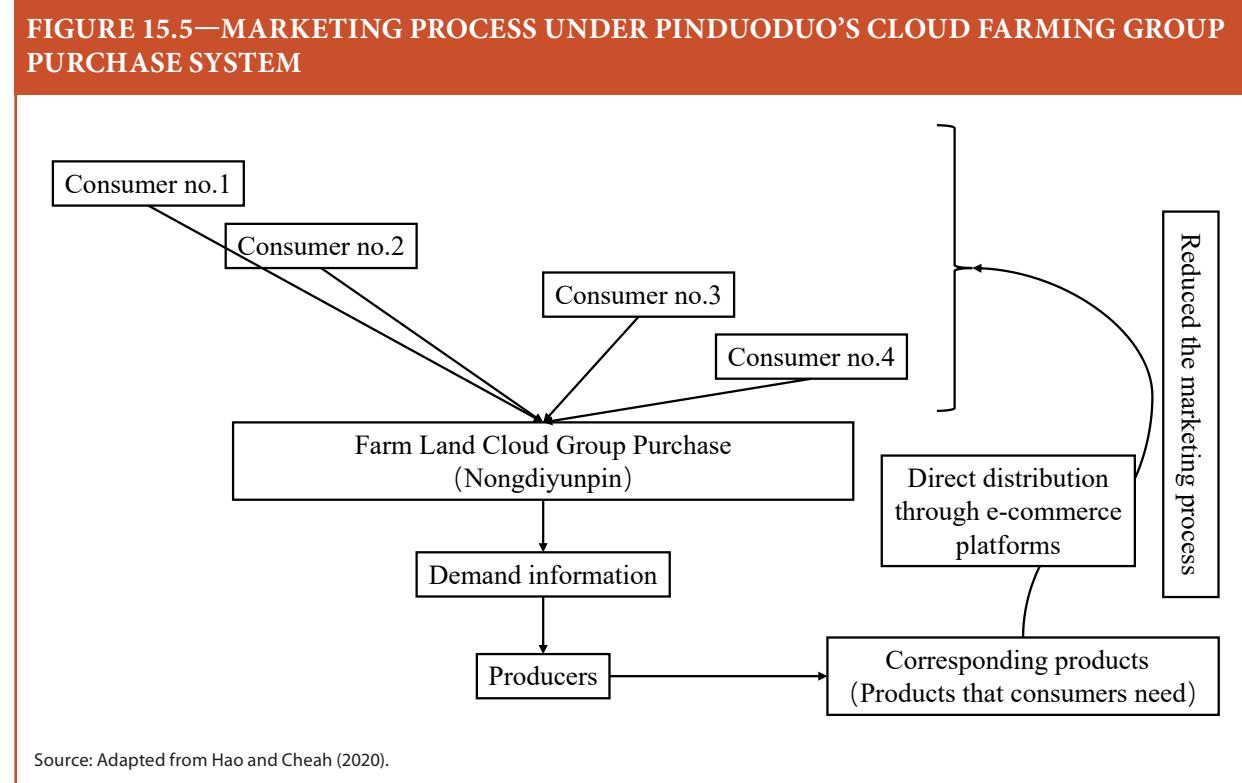
Intelligent Food Storage. Leveraging digital information, automation, and smart sensors within an Internet of Things (IoT) framework, intelligent food storage is an integrated warehousing management system that optimizes and enhances the storage of agrifood products. In China, the application of intelligent food storage systems has significantly improved the efficiency of storage operations. This is particularly crucial in the food industry, especially for perishable items such as fresh fruits, vegetables, and meats, where enhanced storage efficiency directly impacts food preservation and quality. Additionally, the technologies enable real-time monitoring of storage conditions, allowing enterprises to swiftly respond to factors that may lead to food loss, such as temperature fluctuations and excessive humidity.

The intelligent storage market in China has maintained rapid growth in recent years, primarily through the private sector. The market size of the intelligent storage industry in China increased to RMB 153 billion (US\$ 21.5 billion) in 2023, almost doubling in four years. Among the components of intelligent storage systems, automated guided vehicles are most common at 29 percent of all such systems. This is followed by robotic arms, intelligent storage devices, intelligent sorting equipment, and intelligent loading and unloading devices. Nationally, enterprises that reported using intelligent food storage systems in 2022 exceeded 6,100. The Ministry of Commerce and provincial governments have issued relevant policies to support the development of the intelligent food storage industry.

Consumption

Food Demand Prediction. Data analysis, including machine learning, is now gaining

FIGURE 15.5—MARKETING PROCESS UNDER PINDUODUO’S CLOUD FARMING GROUP PURCHASE SYSTEM



widespread use in China to predict food demand. Producers, wholesalers, and retailers use these methods to anticipate changes in market demand better so that they can optimize their production plans and more profitably manage their inventories, thereby reducing food waste, enhancing supply chain efficiency, and meeting consumer needs (Table 15.3). Large e-commerce platforms and major supermarket chains combine historical sales data, weather forecasts, and holiday promotions to construct predictive models to forecast demand for specific items over defined time periods. Food demand forecasting provides a scientific basis for decision-making, allowing corporate management to engage in strategic planning based on predictive outcomes.

The government has supported food demand forecasting development efforts by establishing special funds and projects to encourage agrifood enterprises to pursue technological innovation. Enterprises across several agrifood value chains are establishing their positions in food demand forecasting, with several prominent companies reporting initial success in using predictive models to improve operational efficiency.

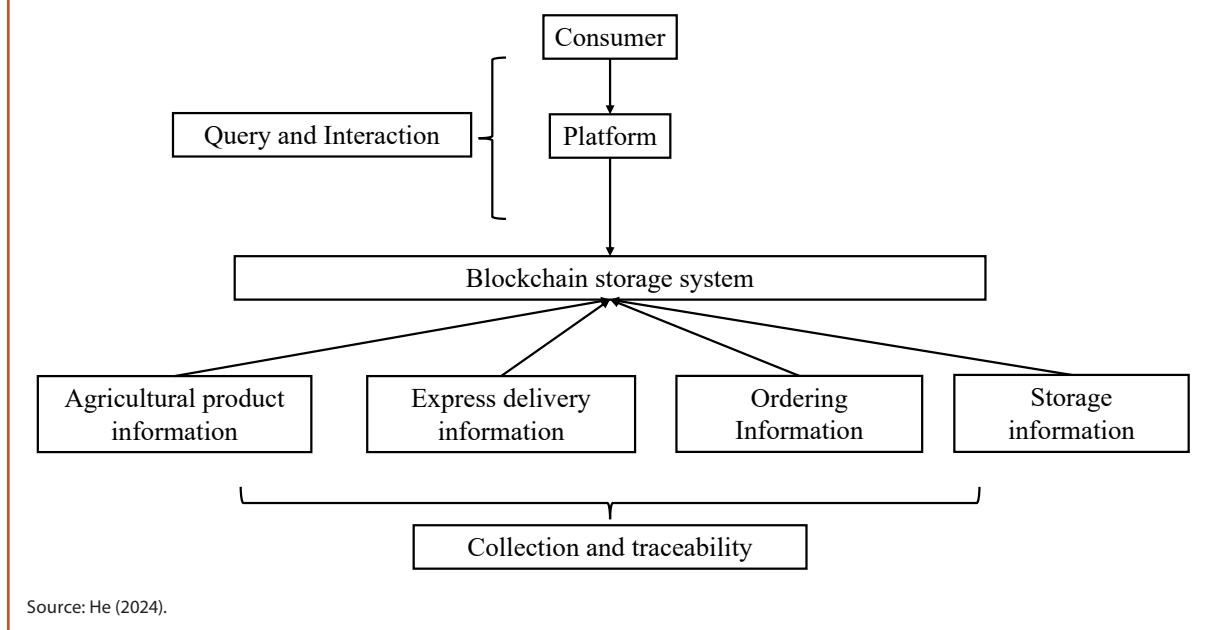
Traceable Agrifood Products. Several forms of information technology, particularly blockchain, big data, and the Internet of Things (IoT), are used to record and track information through the production, processing, transportation, and sales of agrifood products. These technologies ensure that consumers obtain information on the source, production processes, and quality of the products they consume,

TABLE 15.3—DATA ANALYSIS AND EFFICIENCY IMPROVEMENTS IN SEGMENTS OF AGRIFOOD VALUE CHAINS IN CHINA

Segment	Data content	Measures	Effect
Demand forecasting	Historical sales data, seasonal fluctuations, promotional impact, external factors	Time series analysis and prediction modeling based on big data	Improve the accuracy of demand forecasting and reduce inventory backlogs
Inventory management	Real-time inventory data, sales data, inventory turnover rate	Real-time inventory monitoring and adjustments, automatic replenishment, unsold product stocks	Reduce stockouts and improve inventory turnover rate
Production scheduling	Production capacity, input procurement, market demand	Dynamically adjust production line scheduling	Improve production efficiency, reduce overproduction or stockouts
Logistics delivery	Transport pathways, transportation time, storage data	Optimize transportation routes and delivery scheduling to reduce transportation costs	Improve logistics efficiency and reduce resource waste during transportation
Supplier management	Supplier delivery timeliness and product quality data	Optimize supplier selection and sales negotiations through data-based analysis of supplier performance	Improve supply chain stability and reduce supply chain risks

Source: Yuan (2025).

FIGURE 15.6—APPLICATION OF BLOCKCHAIN TECHNOLOGY IN AGRICULTURAL PRODUCT TRACEABILITY



thereby enhancing their trust and satisfaction (Figure 15.6). Through traceability technology, consumers can scan QR codes or enter identification numbers when purchasing products to access detailed agrifood product information. Traceability technology also enhances the efficiency and transparency of the supply chain. For example, producers and retailers can jointly use such technologies to mitigate inventory backlogs and shortages, thereby lowering operational costs for both.

Fifty-eight cities in China have established meat and vegetable traceability systems, covering over 80,000 enterprises and more than 500,000 merchants. The central management platform receives an average of over 4.5 million traceability records daily. Agrifood enterprises, cooperatives, and farmers are all actively participating in this initiative.

Promotion of Technology Adoption in Agrifood Systems in China

China has established an effective national agrifood technology innovation and dissemination system through a three-part framework integrating policy, funding, and stakeholders—strategic planning and policy formulation provides direction, fiscal subsidies lower the threshold for technology adoption, and public-private collaboration activates market dynamics.

Policy support

A multi-layered policy system provides strong support for agrifood technology development and dissemination through strategic planning and platform development. At the national level, the Outline for Innovation-Driven Development Strategy has positioned agricultural technological innovation as a core priority, emphasizing the role of biotechnology and digital technology in modernizing agriculture (CPC-CP and PRC-SC 2016). In parallel, the Fourteenth Five-Year Modernization Plan for Agriculture and Rural Areas prioritizes agricultural mechanization and intelligent technologies and promotes research and innovation in smart solutions for the agrifood sector (MARA 2021).

To do so, China has established a comprehensive network of research platforms covering the entire agricultural technology chain. Key national agricultural laboratories and engineering technology research centers serve

as the backbone for technological breakthroughs. In addition, the Ministry of Agriculture annually selects and funds over 300 agricultural technology promotion projects to align research and development with agricultural production needs. This strategic approach to agrifood technology development and utilization, whereby innovations are taken from design through to implementation, can be replicated across many African countries.

Subsidies and other fiscal support

China employs a multifaceted subsidy system to reduce the costs of technology adoption and encourage its widespread application within the agrifood sector. On the fiscal support front, the central government allocates over RMB 5 billion (US\$ 700 million) annually to support joint technological research and development by farmer cooperatives, agricultural enterprises, and research institutions (MARA 2022). Additionally, local science and technology programs have been developed to provide resources for grassroots technology promotion. These cover over 90 percent of China's counties.

As an example of an agricultural production subsidy, the one for agricultural machinery purchases, implemented since 2004, has provided RMB 200 billion (US\$ 28 billion) of financial support to 33 million farming households and enabled the purchase of over 40 million agricultural machines (MARA 2024). The scope of these subsidies has recently expanded from traditional machinery to include drones and intelligent monitoring devices. Moreover, the government has introduced subsidies for technology promotion service providers, such as agricultural extension stations. Local governments are also encouraged to provide additional support for the adoption of profitable agricultural innovations in key local agricultural sub-sectors. These subsidies not only lower the cost of technology adoption for farmers but also significantly improve agricultural production efficiency and resource utilization.

Stakeholder incentives

China's agricultural technology innovation and dissemination mechanisms emphasize the collaborative role of stakeholders, leveraging incentive policies and participation mechanisms to stimulate the initiative of private enterprises and farmers. For private firms, the government employs a dual-drive mechanism of tax reduction incentives with improved market access to stimulate innovation in

the private sector. Technology enterprises benefit from a corporate income tax rate of 15 percent (reduced from the standard 25 percent) and a 100 percent tax deduction for research and development expenses. The government also supports technology transfer through public-private partnership models, through which companies can receive between 30 and 50 percent of project profits as incentives. Additionally, intellectual property pledge financing allows companies to secure low-interest loans using their patents as collateral—over RMB 12 billion (US\$ 1.7 billion) has been directed to agrifood system activities in this way since 2022.

To engage farmers, the government uses a strategy that involves technology demonstrations along with subsidies to facilitate farmer adoption of the technology. Over 50,000 agricultural science and technology demonstration parks have been established. At these events, farmers can observe, try out, and test new technologies at no cost. For instance, in Heilongjiang province, farmers adopting side-deep fertilization techniques for rice receive subsidies of RMB 200 (US\$ 28.00) per acre, with guaranteed purchase of the surplus yield they obtain. This system, involving public-private collaboration through a demonstration-led process, not only activates market dynamics but also enables informed technology adoption by farmers. With appropriate modifications, such a model for the dissemination of new technologies in the agrifood sector could be replicated in African countries.

Suitability of Technologies in China's Agrifood Systems for Africa

Sources of technology

The research and development (R&D) systems for agricultural and agrifood system technologies in African countries are complex networks primarily composed of three key components: local R&D institutions, international cooperation projects, and collaborations between international organizations and the private sector. While these components contribute to the system's functionality, overall innovation capacity remains relatively weak, and the systems are heavily reliant on international aid and external inputs.

Local R&D institutions in African countries face significant challenges, particularly funding. Agricultural research expenditure in most African nations is low—for example, Nigeria allocates only 0.5 percent of its AgGDP to agricultural R&D, a figure that underscores broader underinvestment in the sector.

There are significant regional disparities in agricultural R&D funding, with countries such as Egypt, South Africa, and Kenya demonstrating stronger capabilities compared to most other African countries. Nonetheless, most depend heavily on international assistance to support their research endeavors.

International cooperation projects seek to strengthen agricultural R&D capacity across Africa. China has established 24 agricultural technology demonstration centers across the continent and has undertaken collaborative research initiatives, such as the China-Kenya Joint Laboratory. These projects focus on technology transfer and localized research, aiming to develop and promote adapted, resilient crop varieties, such as hybrid rice and drought-tolerant soybeans, and water-saving technologies, such as drip irrigation. These efforts have enhanced agricultural productivity while also addressing pressing environmental challenges.

International organizations such as the World Bank and the Food and Agriculture Organization of the United Nations (FAO) provide critical financial and technical support to national agricultural R&D systems in Africa. Additionally, private enterprises are increasingly integrating new digital and other technologies into agrifood value chains, such as by investing in starch processing plants in cassava value chains. However, local private sector engagement remains limited, with many enterprises operating on a small scale and exhibiting limited capacity to absorb and adapt to advanced technologies. African R&D systems are frequently driven by donor priorities, resulting in weak local innovation capabilities and fragmented technology dissemination systems.

To address the challenges in Africa's agricultural R&D system, the adoption of appropriate technologies is essential. Resilient breeding technologies and environmentally adaptive technologies are particularly suitable. These technologies not only improve crop yields but also help address Africa's climatic and environmental challenges. To facilitate their adoption, the establishment of agricultural technology demonstration centers and localized training programs, such as farmer field schools, is recommended to enable farmers to acquire practical skills and master techniques tailored to their specific contexts. Moreover, strengthening international scientific cooperation and leveraging gene-editing and other crop breeding technologies to develop drought-tolerant crops can enhance local innovation capabilities, ensuring the sustainability of agricultural development across African countries.

Types of technology

The transformation of agricultural technology in Africa must strike a balance between environmental adaptability and crop varietal improvement to address the continent's pressing challenges, particularly water scarcity and land degradation. This dual approach ensures that emerging agricultural practices are both productive and sustainable and are adapted to the region's ecological conditions.

Environmentally adapted technologies are crucial for addressing Africa's ecological challenges. Drip irrigation, for instance, has been successfully applied in Chad, doubling rice yields while significantly reducing water usage. This water-saving technology is particularly vital in regions with scarce, irregularly distributed water resources. Similarly, the use of grass and fungus technology in Mauritania has proven effective in combating desertification. By locking sand, the land is protected from further degradation but also enables more sustainable use by livestock, better integrating crop production with pastoralism. Such technologies demonstrate how environmental adaptability can be integrated into farming practices to achieve both productivity and ecological conservation.

Crop breeding improvements will also play a pivotal role in enhancing agricultural productivity in Africa. Resilient breeding techniques, such as hybrid rice and drought-tolerant soybean varieties, have been instrumental in China in improving crop yields and resilience to adverse environmental conditions. These technologies are particularly beneficial in regions prone to drought and erratic rainfall patterns. Molecular breeding technologies that use gene-editing tools have revolutionized crop development. By shortening breeding cycles, high-yielding, disease-resistant crop varieties can be developed quickly, resulting in yield increases of 10-15 percent. The combination of these crop improvement technologies with environmentally adapted technologies ensures that farmers can achieve higher productivity while maintaining environmental sustainability.

To facilitate the adoption of these technologies across Africa, multifaceted approaches are necessary. Demonstration centers and field schools can serve as platforms for training farmers. The integration of digital technologies and tools, such as AI-based pest and disease diagnosis systems, can expand the reach and effectiveness of agricultural extension services. By leveraging these technologies, African agriculture can combine environmental adaptability and high-yielding crop varieties, paving the way for sustainable agricultural development.

Types of users of agrifood technologies

In African agrifood systems, the primary users of agricultural technologies include smallholder farmers, agricultural cooperatives, and local governments. Each of these user types has distinct capacities and needs, which must be carefully considered when designing and implementing technology adoption strategies.

Smallholder farmers represent the largest group of agricultural users in Africa, making up 80 percent of the agricultural population. However, despite their numerical dominance, they face significant challenges that hinder their ability to adopt and utilize advanced technologies. Only 15 percent of smallholder farmers have received formal agricultural training, indicating a critical knowledge gap. Financial constraints further exacerbate this issue, as many lack the resources to invest in high-cost technologies. Additionally, their reliance on rain-fed agriculture makes them particularly vulnerable to climate variability and water scarcity, further limiting their ability to adopt technologies that require significant upfront investment.

Agricultural cooperatives play a crucial role in the agrifood sectors of several African countries, pooling the resources of their members to achieve economies of scale. However, despite their potential, cooperatives are often constrained by limited management capacity and funding flows, which hinder their ability to adopt and implement new technologies. Local government policy support for cooperatives is often insufficient, and inter-departmental coordination capabilities within government are weak, further complicating the implementation of agricultural development plans. These challenges suggest a need for external technical support and capacity-building initiatives to strengthen technology adoption and dissemination by cooperatives.

To address the diverse needs and capacities of these user types, a targeted approach to technology adoption is required. Technologies that are well-suited to smallholder farmers include small agricultural machinery, such as micro seeders, which can improve efficiency by 50 percent while remaining affordable. Digital remote services, such as training, also offer a promising solution, enabling farmers to access knowledge and guidance without the need for in-person training.

To facilitate the adoption of these technologies, cooperatives are central as they collectively purchase seed, appropriate agricultural technologies, and other

inputs for their members, while also providing technical guidance to them. This approach reduces costs and ensures that technologies are tailored to farmers' specific needs. In addition, offering remote digital training and technical support can further enhance farmers' capabilities, ensuring that they are able to utilize the technologies they adopt effectively. Such strategies will better match technology and user needs, thereby improving agricultural production efficiency and promoting the sustainable development of African agriculture.

Technology promotion

The environment for agricultural technology promotion in Africa is marked by both significant opportunities and challenges, particularly in terms of infrastructure, technical service capabilities, and policy support. Despite the potential for transformative change, the region faces systemic limitations that hinder the effective adoption and dissemination of agricultural technologies.

One of the most pressing challenges in Africa's agricultural technology promotion environment is the lack of adequate infrastructure. Only 30 percent of rural areas have year-round accessible roads, making it challenging to transport inputs and outputs and provide technical services. This logistical bottleneck is further compounded by limited irrigation coverage, at less than 7 percent, leaving farmers dependent on often unpredictable rainfall. Post-harvest losses exacerbate the problem, reaching as high as 35 percent, due to inadequate storage and processing facilities. These infrastructure deficiencies not only reduce agricultural productivity but also discourage farmers from adopting new technologies, as the benefits may be negated by inefficiencies in processing and distribution within crop value chains.

Technical service capabilities are another critical area of concern. National agricultural extension systems across Africa remain underdeveloped, with a shortage of trained agricultural technicians to guide farmers. This makes it difficult to meet growing demands for technical assistance, particularly among smallholder farmers who lack the knowledge to adopt advanced technologies. Additionally, policy and funding support for technology promotion in agrifood systems is insufficient. Despite development goals aimed at boosting agricultural productivity and investment in agrifood systems, many African governments have not fully implemented the strategies to achieve these objectives. This lack of commitment restricts the large-scale dissemination of technologies, further widening the gap between potential and actual agricultural productivity.

A combination of targeted strategies is required. Many agricultural technologies, such as drip irrigation, small agricultural machinery, and digital tools, such as AI-based pest and disease diagnosis systems, are well-suited for use by smallholder farmers in Africa. These technologies are not only cost-effective but can also be adapted to perform well under the diverse agro-ecological conditions across Africa. To facilitate their adoption, it is essential to expand infrastructure investments, such as improving road networks and expanding irrigation coverage, which can create a more conducive environment for technology adoption.

Additionally, leveraging international partnerships can help bridge funding gaps and enhance technical service capabilities for African smallholders.

Demonstrating the practical benefits of technologies through pilot projects and demonstration centers can also encourage farmer adoption. Digital tools, such as mobile apps for agricultural extension services, can expand the reach of technical assistance, particularly in remote areas. By addressing infrastructure deficiencies, strengthening technical services, and enhancing policy support, countries across the continent can create a more favorable environment for the promotion of agricultural technology. This will improve productivity and enhance the livelihoods of millions of smallholder farming households.

South-South Cooperation to Transfer Agrifood Technologies to Africa

Scientific research and innovation

South-South cooperation in agricultural and agrifood technology innovation—such as between China and African countries—should focus on establishing joint research institutions to promote technology sharing and localized adaptation. By co-building laboratories and research centers, resources can be integrated to conduct targeted research and develop resilient crop varieties and water-saving technologies suitable for environmental conditions on the continent. Additionally, strengthening the talent pool in agricultural research through scholarships, training, and academic exchanges can enhance the capabilities of African researchers and promote local innovation capacity.

China has advanced agricultural technology innovation in collaboration with several African countries. The China-Africa Joint Research Center at

Kenya's Jomo Kenyatta University of Agriculture and Technology has conducted research on biodiversity conservation, the effectiveness of demonstrations for agricultural technology adoption, and disaster early warning systems, resulting in over 600 published papers and the training of 320 African students. Similarly, the China-Kenya Joint Laboratory at Egerton University has utilized gene-editing technology to select drought-tolerant varieties of edible beans, which have since been released to farmers.

China can further enhance such joint research with African countries, focusing on developing resilient crop varieties and adapted technologies to meet the diverse needs of African farmers. Additionally, increasing efforts to train African research talents through special funds or scholarships can attract more young African scholars to study in China, thereby enhancing local innovation capabilities.

Technology promotion

South-South cooperation in technology promotion should emphasize a farmer-centered model that directly assists African farmers in mastering and applying advanced technologies through demonstrations, training, and guidance. During the promotion process, it is essential to select low-cost, high-benefit technologies that align with the realities of farming in Africa and to expand coverage through digital means. Moreover, local adaptation of technologies should be strengthened to ensure effective implementation in diverse regions and environments.

China has promoted agricultural technologies through various methods, including the deployment of technical experts, training, and the establishment of demonstration centers. China has sent over 400 agricultural experts to Africa, training over 1,000 technicians to help African farmers improve their technical skills. Collaboration between researchers from the Chinese Academy of Agricultural Sciences and Nigerian agricultural scientists on greener pest-control methods has reduced control costs by 35 percent. Field schools have also been used in Nigeria to promote yield-increasing technologies in rice at demonstration centers. China can optimize the technology promotion models it supports in its work with African partners by, for instance, using digital remote service platforms to conduct online training and technical guidance. Promoting smaller-scale technologies, such as hand-cranked soybean milk machines and solar-powered agricultural machinery, can help smallholders improve their production efficiency.

Trade cooperation

South-South cooperation in trade should focus on promoting African agrifood products by simplifying export processes, reducing trade barriers, and strengthening brand building to help them enter broader global markets. Continued investments in agrifood value chains, particularly in processing and logistics, will increase the value added to African agricultural products. Establishing and expanding e-commerce platforms can lower the costs and risks associated with African agricultural products entering the Chinese market. For example, in 2024, Rwandan honey was shipped directly to the Chinese market through e-commerce platforms. China's investments in agrifood value chains in Africa have significantly improved farmer incomes. For example, a rubber processing plant in Côte d'Ivoire increased farmers' income by US\$ 300-600 per mt, while also expanding local logistics employment to support factory operations. Strengthening cold chain logistics and processing facilities similarly can enhance the competitiveness of African agricultural products in international markets. Finally, trade engagement platforms, such as the Forum on China-Africa Cooperation, can encourage more African countries to participate in global agrifood value chains, enabling their farmers and agrifood processors to use their agricultural resources more efficiently and maximize the economic benefits.

Business models

South-South business cooperation should emphasize innovation and sustainability. This includes exploring models that include access to technologies or risk mitigation measures, such as insurance, to reduce the operational risks faced by African farmers adopting new technologies. Public-private partnership models can also help, particularly in attracting more social capital for agricultural technology transfer and industrial development. Additionally, empowering youth and women through specialized training and entrepreneurship support will enable more comprehensive development in Africa's agrifood systems.

China has supported the transfer and industrial development of agricultural technology in Africa through various business models. For instance, Jihai Agricultural invested in a mushroom factory in Zambia, employing 200 local workers and achieving an annual output value of US\$ 5 million, with the firm providing both the technology and market for the enterprise. Additionally, the Africa Agricultural Modernization Fund, established by the Forum on

China-Africa Cooperation, supports the construction of cold-chain logistics and processing facilities. China can further leverage the advantages of the public-private partnership model by increasing investment in smaller-scale technologies, such as appropriately adapted agricultural machinery. Additionally, China can help efforts to expand weather index insurance for farmers across Africa to reduce their vulnerability to climate risks that affect the returns they obtain from using new technologies.

Conclusion

China has developed a robust agricultural technology transfer model both domestically and, increasingly, in its partnerships with countries in Africa. These are characterized by comprehensively linking demonstration and training with the commercial application of the technologies within agrifood value chains. This approach showcases advanced agricultural techniques for farmers, while also empowering them and their communities with the knowledge and resources needed to sustain improved productivity. Through this model, China has established agricultural demonstration centers across Africa where innovative, locally adapted farming practices are demonstrated. These centers not only demonstrate the practical benefits of such technologies but also provide hands-on training to farmers, enabling them to adopt and adapt these practices. Additionally, integrating a value chain perspective ensures that the benefits of technological adoption extend beyond individual farms, contributing to broader economic and social development.

Looking ahead, there is significant potential to deepen the application of digital technologies that have been successfully deployed in agrifood value chains in China to African agriculture. Tools such as AI driven pest and disease diagnosis systems, digital extension platforms, and precision agriculture applications can enhance efficiency, reduce losses, and improve decision-making for African farmers. Strengthening localized cooperation mechanisms, such as public-private partnerships and farmer cooperatives, will be critical to ensuring the long-term sustainability of these efforts.

Through South-South cooperation, China is well positioned to support African countries in overcoming resource and environmental constraints, while also contributing replicable solutions to global agricultural sustainability.

This partnership aligns with the vision of a shared future and aims to elevate agricultural collaboration to new heights. By sharing its agricultural expertise and experiences, China can not only help address food security challenges in Africa but also contribute to more resilient and interconnected agrifood systems globally.