From Chinese Experience
To African Practices

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Achieving Africa' s Food Security by Integrated Nutrient Management and Smallholder Empowerment

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Key Messages

- Chinese and African agriculture share significant similarities in being dominated by smallholder farming and facing pressures from population and consumption growth along with resource constraints. However, Africa's crop yields remain significantly below global and Chinese averages.
- China's experience in grain production is two-sided: it feeds 22% of the world's population with only 9% of the world's arable land, but it consumes 35% of the world's fertilizers. This comes with great resource cost and environmental consequences.
- In the future, African agriculture could benefit by drawing on China's technological and policy experiences while avoiding the pathway of "pollute first, control later" and exploring sustainable development models suited to Africa' s local conditions.

Recommendations

We propose three specific actions to increase agricultural production for achieving African food security, improving soil health, and addressing climate change:

- Promote the "three-field" rotational cropping model: African smallholder farmers divide their land into three zones to rotate between grain crops, cash crops, and nitrogen-fixing crops. They also use compost pits to produce organic-inorganic compound fertilizers to achieve the co-benefits of soil fertility improvement and income growth.
- Encourage a soil improvement plan with "integrated cropping-livestock systems" at a large scale: Households raise cattle, sheep, and chickens and prioritize the application of organic fertilizer to nearby land to enhance soil fertility. This complements poverty reduction, emissions reduction, and resource recycling efforts.
- Implement the Science and Technology Backyard Project as pioneered by China Agricultural University to motivate the intrinsic development motivation and capacity of African smallholders.

Introduction

China, the world's largest developing nation, and Africa, the continent with the highest concentration of developing countries, share agricultural landscapes dominated by smallholder farming. Both also face analogous challenges in land resource constraints, government policy roles, and structural dynamics[1]. Over the past five decades, driven by technological advancements particularly the rise of the fertilizer industry and strong government support, China has achieved food self-sufficiency and remarkable agricultural productivity through optimized nutrient resource management, successfully feeding 22% of the global population using just 9% of the world's arable land. In stark contrast, with 19% of the world's arable land, the fastest-growing young labor force globally, and its potential to become the "global granary" [2]; Africa' s average grain production has long hovered around 2 t ha^{-1}, lagging far behind the global average (4.2 t ha^{-1}) and China's average (6.4 t ha^{-1}), and resulting in 300 million people in Africa still suffering from hunger and malnutrition[3,4]. Given the similarities between the two regions and the pressure on food supply in Africa, Africa could learn many successful experiences and practices from China to address food security issues.

On the other hand, while China has addressed the food security needs of 22% of the global population, it has also consumed as much as 35% of the world's fertilizers, incurring significant resource and environmental costs, including soil acidification and water eutrophication[5,6]. As Africa seeks to enhance its food production capacity, it would benefit by learning from China's experiences and avoid following a pathway of environmental degradation. To this end, we examine the historical evolution of China's food production and fertilizer industry development, analyze the role of technological progress (especially fertilizer industry development) and policy drivers in addressing China's food security issues, and compare these with Africa's food production processes to provide some experience and insights for addressing Africa's food security challenges. If Africa can avoid following China's pathway of polluting first and then addressing the consequences, it will be able to pursue a sustainable food production pathway with unique African characteristics. Strengthening China-African cooperation in fertilizer and crop nutrition development by leveraging China's proven expertise could be instrumental in elevating African agricultural productivity, safeguarding food security, and exemplifying impactful South-South cooperation on the global stage.

The Evolution of Fertilizer Industry Development and Fertilizer Use in China

China's fertilizer industry emerged in the early 20th century and in the meantime has transformed from high reliance on imports to domestic production, from single products to diversified ones, and from quantity-driven growth to quality improvement. This evolution can be broadly divided into four stages.

1) Inception & Early Development: Before 1970, China's fertilizer industry was small in scale, highly reliant on imports, and primarily focused on single component nitrogen fertilizers such as ammonium sulfate, with nearly all phosphorus fertilizers imported.

2) High-Growth Era: Around 1990, high-concentration nitrogen fertilizers (urea) dominated the market.The phosphate fertilizer industry developed rapidly, with high-concentration phosphate fertilizers (such as diammonium phosphate) beginning production. Compound fertilizers (especially nitrogen-phosphorus-potassium fertilizers) began to be promoted.

3) Technology Upgrading Era: Around 2010, high-concentration fertilizers dominated the market. Urea remained the primary nitrogen fertilizer, while ammonium bicarbonate largely withdrew from the market; high-concentration phosphorus fertilizers (dicalcium phosphate/monocalcium phosphate) became the mainstream; demand for compound fertilizers surged, making them the farmers' top choice.

4) Quality-Driven Development Era: Around 2015, in response to environmental issues caused by excessive chemical fertilizer use, the state has implemented a "reduce fertilizer use, enhance efficiency" policy, driving the industry toward green, efficient, and precise transformation[7]. Traditional fertilizers (urea, high-concentration phosphorus and potassium fertilizers) are undergoing structural optimization, with a focus on efficiency and environmental protection. Innovative fertilizers are developing rapidly: controlled-release fertilizers reduce nutrient loss; organic-inorganic compound fertilizers enhance soil fertility; water-soluble fertilizers are well-suited for modern agriculture and are growing rapidly.

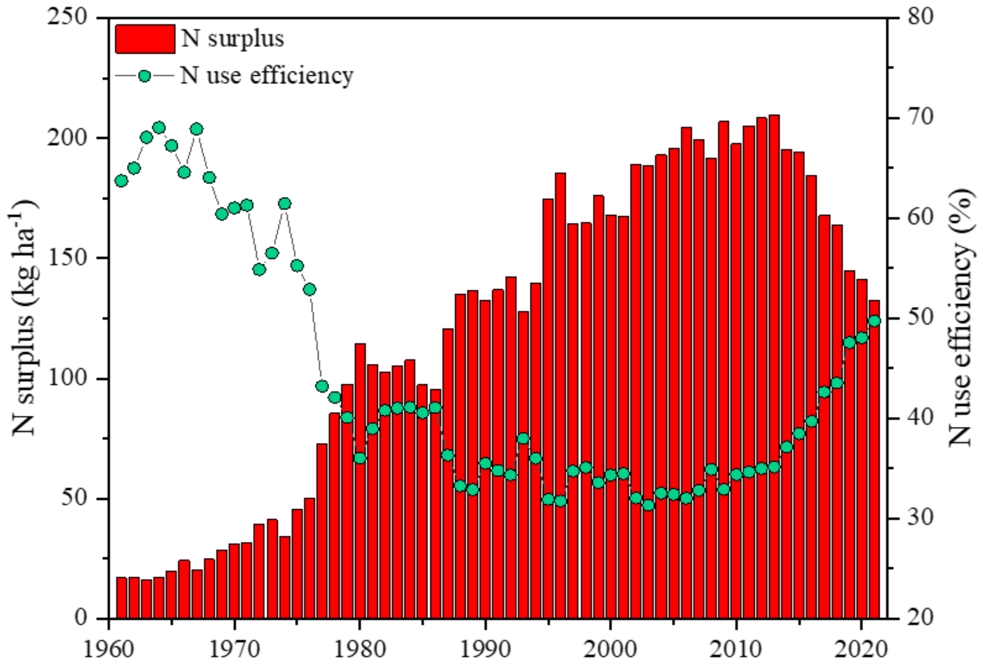


Figure 1a: N surplus and N use efficiency in China's staple crop production since 1960

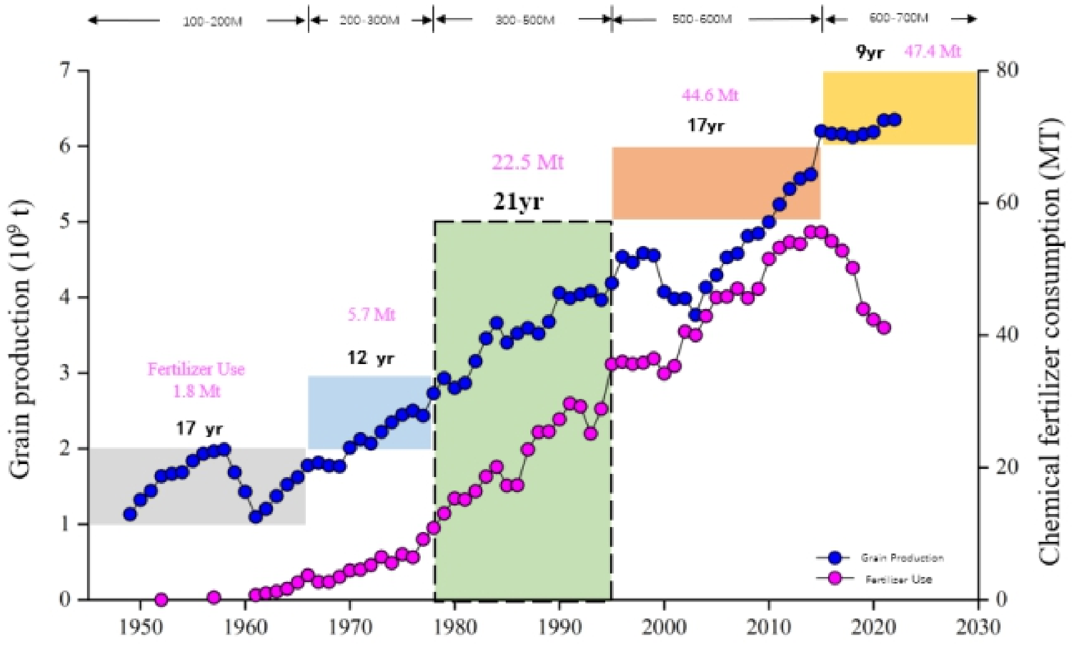
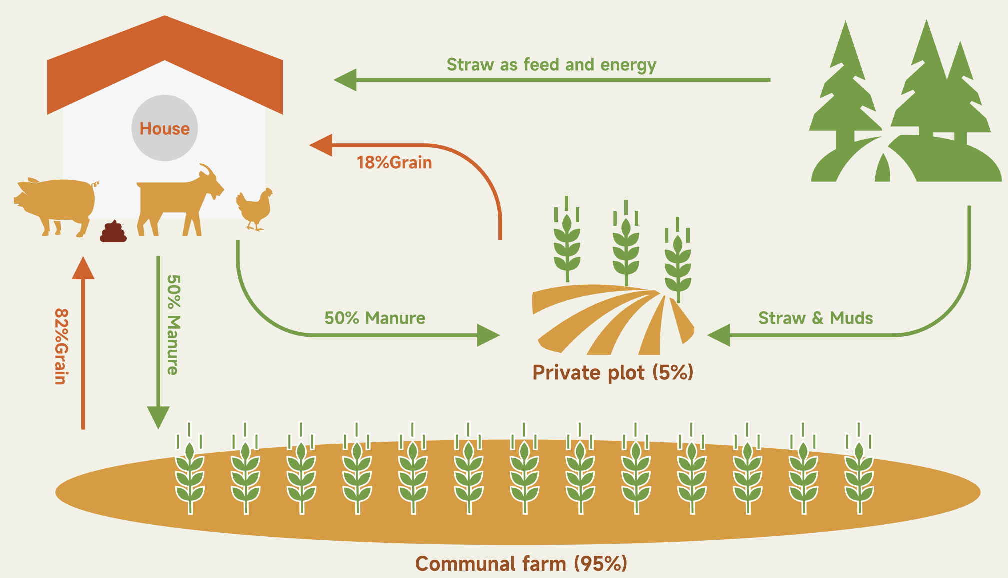


Figure 1b: Dynamic trajectories of grain production and chemical fertilizer consumption in China from 1949 to 2022

Over the past five decades, China's fertilizer use has followed a path from "supply shortage → rapid growth→ excessive application → optimized fertilization". Fertilizers have been key to China's growth in grain production, contributing 40–50% of the increase in grain output[8]. Before the 1970s, China's fertilizer industry was underdeveloped, and agricultural production primarily relied on traditional organic fertilizers such as manure, with limited fertilizer use. Farmers utilized all available organic resources to improve soil fertility (see for details). From the 1970s to the 1990s, the widespread adoption of fertilizers, combined with irrigation and high-yielding seeds, led to a significant increase in grain production, with fertilizers contributing over 80% of the increase[9,10]. At this time, fertilizer use was primarily guided by fertilizer effect curves. In the 1990s, China blindly increased fertilizer application in pursuit of high yields, leading to lower nutrient use efficiency (nitrogen use efficiency below 30%, far below the developed countries' average of 50%-60%), resource waste, and severe environmental issues (soil acidification, water eutrophication, etc.)[11]. Since the 2010s, especially after the Ministry of Agriculture and Rural Affairs implemented the "zero growth in fertilizer use" policy in 2015, China has vigorously promoted scientific management methods such as soil-testing-based formula fertilization. Based on soil test results and crop nutrient requirements, customized formula fertilization plans are developed. Fertilizer use efficiency has significantly improved to as high as 42%, effectively reducing waste, optimizing nutrient structures, and increasing grain production while lowering environmental risks[12,13].

In Nutrient-poor Soil Era, Chinese Farmers Use All Available Organic Resources To Produce Organic Fertilizers For High Soil Fertility.

From the 1950s to the 1980s, China's farmland was collectively managed, with 5% reserved as private plots managed by individual members. Compared to collectively managed land, private plots exhibited significantly higher grain yields and soil fertility. For instance, the soil organic matter content in private plots was more than twice that of collectively owned land, and maize yield reached 8 t ha^{-1} in private plots, whereas collectively owned land yielded only 4 t ha^{-1}. A key reason for this was the management practices employed by farmers on their private plots. Farmers collected all available organic waste, such as riverbed silt, straw, and leaves, composted it to produce organic fertilizer, and returned it to their private plots. Additionally, they used straw and leaves to feed animals, and the organic fertilizer produced by the animals was returned to the fields, further enhancing the fertility of the private plots. In those days, every farmer's household had a manure pit, which served to compost and ferment organic waste into organic fertilizer. Farmers used a greater proportion of the organic fertilizer produced on their farms for their private plots, and this concentrated use of limited resources to enrich the soil greatly promoted the improvement of soil fertility in their plots.



Typical approach for smallholders to use manure for improving soil fertility in the 1970s

Status Quo of Fertilizer Use in Africa

The amount of synthetic fertilizer use in African cropland is significantly low. The current average fertilizer application rate is approximately 20 kg N ha^{-1}, far below the global average (approximately 140 kg N ha^{-1}) and also failing to meet the target of 50 kg ha^{-1} set by the Abuja Declaration[14]. The primary reasons for such low rates are as follows:

- **High reliance on imports:** Limited domestic fertilizer production capacity results in high dependence on imports, making the sector vulnerable to fluctuations in international market prices and supply disruptions.
- **Incomplete market system:** The fertilizer market distribution network is weak, with multiple intermediaries, unstable supply, and low efficiency.
- **High logistics costs:** Outdated transportation infrastructure makes it difficult and expensive to transport fertilizers from ports to farms, significantly increasing final prices.
- **Difficulty for farmers to access fertilizers:** Smallholder farmers have limited purchasing power and cannot bear the high initial costs of fertilizers, and they generally lack access to credit support.
- **Lack of knowledge on applying chemical fertilizer scientifically:** Many farmers lack understanding of the benefits of fertilizers. They also lack the knowledge and guidance to appropriately select and apply fertilizers based on soil nutrient status and crop nutrient demands.
- **Soil degradation:** Widespread soil degradation issues limit the effectiveness of chemical fertilizer use.

The Development and Evolution of Africa's Fertilizer Industry and Market

Since the 1960s, Africa's fertilizer industry has transformed from heavy reliance on imports to seeking domestic production, but overall, it still falls far short of meeting agricultural production needs.

1. Heavy Import Dependence (Pre-2000): African countries generally lacked fertilizer production capabilities, which led to complete reliance on imports. Weak industrial foundations and exorbitant prices far exceeded the affordability of smallholder farmers, resulting in extremely low fertilizer adoption rates.

2. Industrial Transition & Policy Support Era (Post-2000): African countries began prioritizing domestic fertilizer production and introduced supportive policies. In 2006, the African Union launched the "African Green Revolution in Agriculture" (AGRA) initiative, prioritizing fertilizer promotion as a key strategy to enhance agricultural productivity. Countries such as Nigeria, Egypt, and South Africa subsequently established domestic fertilizer plants. For instance, Nigeria leveraged its natural gas resources to increase investment, boosting production capacity to nearly 20 million tons, making it one of Africa's largest producers and reducing reliance on imports.

Despite progress in domestic fertilizer production, the overall scale of Africa's fertilizer industry remains insufficient to meet agriculture production demands, with imports still the primary source. Continuously enhancing domestic production capacity and reducing farmers' usage costs remain key challenges for Africa's agricultural development.

China's Nutrient Management Experience Advising Sustainable Agricultural Development in Africa

1) Enhance Soil Fertility to Revive Dormant Productive Potential of African Farmland

China's traditional agriculture laid the foundation for the sustainable development of modern agriculture by using organic resources to enhance soil fertility, offering a valuable model for Africa to emulate. (a) Maximizing the use of organic fertilizers: Before the widespread adoption of chemical fertilizers, China extensively used organic resources such as human and animal manure, compost, and green manure for nutrient cycling. This approach effectively improved soil organic matter content, enhanced nutrient supply capacity, and stabilized soil structure[15]. (b) Straw return to fields and green manure cultivation: With technology advancements, China has gradually promoted straw return to fields and green manure cultivation. These measures not only increase soil organic matter but can also enhance soil water retention capacity and significantly improve nutrient use efficiency[16]. (c) Integrated agricultural systems: Some regions in China have adopted "rice-fish-duck" or "fruit-livestock-biogas" circular agricultural models, which recycle waste resources and establish an ecologically friendly nutrient management system[17]. Soil quality in Africa is generally low, but there are abundant underutilized organic resources in African agriculture and natural environments, including agricultural waste, livestock manure, kitchen waste, forestry residues, and aquatic plants. In Africa, smallholder farmers could be encouraged to adopt pit composting or surface composting, which would include controlling the carbon-to-nitrogen ratio, adding microbial agents to accelerate decomposition, regularly turning the compost piles, and maintaining moisture and temperature. Policy support and technology training appropriate to local conditions may be needed to promote simple and effective composting technologies that enhance soil fertility.

2) Develop Fertilizer Industry, and Introduce New Fertilizer Technologies Prioritizing Nitrogen Fertilizer

The rise of China's fertilizer industry has provided a stable and strong foundation for agricultural modernization, particularly in terms of technological progress and industrial scale. By drawing on China's experience, local fertilizer industry development can be established in Africa, while introducing foreign investment and technology cooperation to support agricultural development at the regional level. Additionally, the potential of Chinese enterprises' overseas investments can be tapped to assist the local development of the fertilizer industry. For example, China has established a fertilizer plant in Zambia, which, through regional cooperation, reduces fertilizer prices, ensures widespread supply, and effectively controls prices, thereby enhancing market supply stability and providing long-term support for African agricultural modernization. Such cooperation not only reduces African countries' reliance on imported fertilizers but also creates job opportunities and drives economic development.

3) Balance Food Security and Environmental Stewardship

China's fertilizer industry has transformed from reliance on single nitrogen fertilizers to diversification and sustainability, particularly in response to reflections on environmental and resource issues[18]. As African countries advance agricultural modernization, they have an opportunity to learn from China's experience and avoid over-reliance on single fertilizers. By promoting the production and application of compound fertilizers, organic fertilizers, and bio-fertilizers based on each country's agricultural realities, and by implementing precise fertilization, and strengthening agricultural environmental protection policies, Africa can avoid the soil degradation and environmental pollution issues that China once faced. Additionally, China's experience in technology innovation and policy support provides a significant reference for African countries seeking to enhance fertilizer production and usage levels, advance agricultural modernization, and pursue a green path to increased grain production.

China's Nutrient Management Practices as Lessons for Africa

1)Fully Use Organic Resources to Enhance Soil Fertility

Organic fertilizers are produced by composting various organic wastes (such as crop straw, weeds, leaves, organic household waste, kitchen waste, sludge, human and animal manure, distillers' grains, fungal residues, and other waste materials) through the process of decomposition[19]. Small-scale farmers often source their composting materials from organic waste generated in daily life and agricultural production, embodying the simple wisdom of "turning waste into treasure." For example, agricultural waste such as wheat, corn, and rice straw, livestock manure mixed with straw (including pig manure, cow manure, and chicken manure), fruit peels, vegetable leaves, and leftover food are all raw materials for composting (Figure 2). Transforming waste into "black gold" not only continues traditional agricultural wisdom but also integrates modern scientific management[20]. Application of compost to fields effectively increases soil organic matter, improves soil structure, supplements soil nutrients, promotes microbial activity, and can also regulate soil acidity and alkalinity.

Figure 2: Common composting in Africa

2) Enhancing Biological Nitrogen Fixation and Intercropping Systems

China has a long-standing tradition of using intercropping and relay cropping techniques for soil fertility improvement. Whether it be the ancient practice of legume green manure rotation or the modern intercropping and relay cropping systems, these techniques have played a significant role in smallholder food production[21,22]. These methods not only help increase grain yields but also protect and enhance soil fertility over the long term. Biological nitrogen fixation refers to the symbiotic relationship between leguminous plants and microorganisms such as rhizobia, which convert atmospheric nitrogen into plant-available nitrogen (such as ammonium ions) through nitrogen fixation, providing a nitrogen source for soil and crops. Biological nitrogen fixation is the primary nitrogen source for smallholder farmers[23]. After the founding of the People's Republic of China, the promotion of scientific planting techniques further strengthened the cultivation of leguminous crops and the application of biological nitrogen fixation. For example, in the rice-legume rotation system, planting soybeans, mung beans, and other crops improves soil fertility.

Figure 3: The role of nitrogen-fixing plants in improving soil fertility in Africa

In response to the issue of excessive fertilizer use in China's agricultural fields, in 2005, the Ministry of Agriculture and Rural Affairs, in collaboration with the Ministry of Finance, launched the Soil Testing and Fertilizer Formulation Project, which was also included in the Central Government's No. 1 Document that year. The project established technology standards through five key phases: soil testing, fertilizer formulation, fertilizer blending, fertilizer supply, and fertilizer application. It promoted initiatives such as the "Scientific Fertilization in Hundred Counties and Thousand Towns" campaign and disseminated formulated fertilizers through cooperatives and direct supply models. The project significantly improved fertilizer utilization efficiency, with nitrogen fertilizer use efficiency for major grain crops (such as wheat, rice, and corn) increasing from 30%-35% in 2005 to over 40% currently. Following the promotion of soil testing and formula-based fertilization, farmers have reduced their average fertilizer usage per acre by 10%-15%, yet grain yields have steadily increased. Most importantly, soil testing and formula-based fertilization now covers over 90% of the country's arable land, with a three-tiered technical promotion network established at the provincial, municipal, and county levels. This initiative has achieved a policy-driven, technology-innovative, and farmer-enterprise collaborative approach, driving a transformation in farmers' fertilizer application practices from "blind fertilization" to "precision nutrient management."

3) Soil Testing and Fertilizer Recommendations

Soil testing with targeted fertilizer recommendation uses scientific methods to determine the nutrient status of soil and the fertilizer needs of planned crops[24]. By combining crop nutrient requirements, soil nutrient supply capacity, and fertilizer efficacy, this approach provides crops with the appropriate amount and type of nutrients, achieving precise fertilization. It is an important measure for improving fertilizer utilization rates, reducing agricultural production costs, and protecting the ecological environment[25]. In China's crop production, this technology is effectively addressing the issues of waste and pollution associated with fertilizer use, improving nutrient use efficiency, grain yield, and quality, while also promoting agricultural green development. It is an integral part of modern agriculture.

4) Green Smart Fertilizers and Modern Agriculture

Green smart fertilizers are based on the principle of dynamic matching between crops, soil, and the environment[26]. They are designed using big data algorithms and produced using green manufacturing processes. These fertilizers feature precise nutrient release, root-zone stimulation, and full resource utilization. Their core functionality lies in intelligently regulating nutrient release curves to achieve "supply as needed", thereby reducing resource waste and environmental risks from the source. By precisely matching nutrient supply and demand (technical layer), activating crop biological potential (biological layer), and linking to a circular economy (system layer), it reconfigures the "resource-production-environment" relationship chain[27]. For Africa, green intelligent fertilizers could become a powerful tool for achieving local agricultural green transformation.

5) Establishing Multi-Stakeholder Innovation Platforms to Promote Scaling Up of Scientific Fertilization Technologies

The "Science and Technology Backyard" project in China, now expanding into Africa, provides small-scale farmers with "Four Zeros" services, offering knowledge + products, knowledge + agricultural technology, and other social services to stimulate their development motivation[28]. For African small-scale farmers, the "Four Zeros" services concept (zero distance, zero time-lag, zero barriers, zero costs) could provide scientific knowledge with corresponding products and social services, innovating technical application models to form a "knowledge + products", "knowledge plus agricultural technology". This has potential to further stimulate the intrinsic development motivation and capacity of smallholder farmers[29]. Additionally, smallholder farmers could participate in cooperatives or collective agricultural models to promote intensive production, enhance application effectiveness of agricultural technologies, and drive sustained agricultural efficiency improvements and farmer income growth.

China Agricultural University established a STB in Malawi.

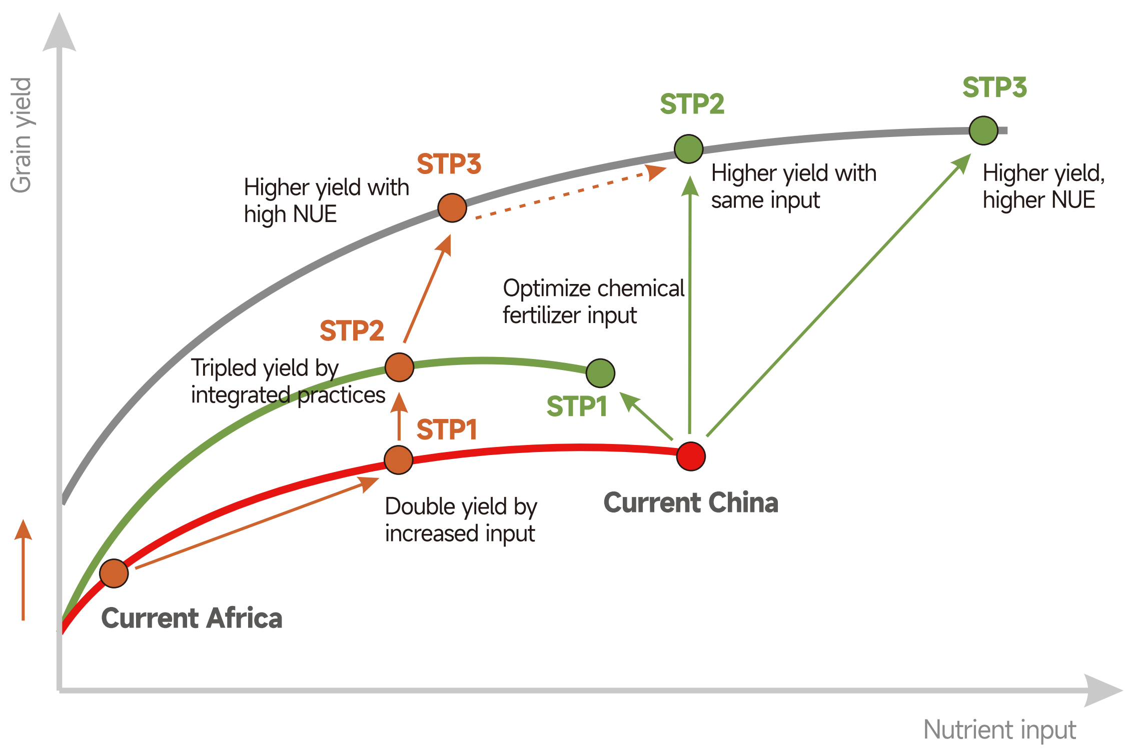
The Science and Technology Backyard (STB) is an innovative rural agricultural science and technology service model pioneered by the team of Academician Zhang Fushuo from China Agricultural University. It involves collaboration between research institutions, universities, and farmers, with the core objective of promoting agricultural science and technology services. By stationing researchers and graduate students in rural areas, the STB directly integrates with farmers' production practices to develop and test advanced agricultural technologies and concepts, thereby achieving increased agricultural productivity, higher farmer incomes, and improved rural ecological conditions. The core operating principle of the STB is "research at the grassroots level, service to the grassroots, and technology empowerment," which means using scientific research and technology promotion as drivers, and through farmer participation and demand-oriented approaches, to achieve the promotion and practical application of agricultural technology. By 2025, China had established more than 2,000 STBs, covering over 200 crop systems nationwide, directly serving more than 200,000 farmers, and achieving significant results.

The China-Africa STBs were established in Africa beginning in Quzhou were based on the decade-long operation of the STB in China, aiming to leverage Chinese experience to empower African smallhold-ers to increase food production and income. Since its initial implementation in Malawi, the initiative has effectively integrated the efforts of governments, enterprises, universities, and international organizations, increasing grain yields on participating farms from 2 t ha^{-1} to 8 t ha^{-1}. It has left behind five comprehensive green grain-increasing technologies for the local area, trained over 200 lead farmers, and sown the seeds of science and technology across the African continent.


Malawi's farmers enjoyed a bountiful corn harvest

China-Africa Nutrient Management Cooperation Strategy and Recommendations

The above analysis of China-Africa nutrient management shows how promotion of Chinese agricultural technology and product innovation can enhance African agricultural productivity and help address its food security issues. A three-step strategy for China-Africa nutrient management coopera-tion is proposed (Figure 1) to strengthen South-South cooperation, promote the transformation of agricultural production models, and advance global food security using principles of green, low-carbon agricultural development[30].



Framework of nutrient management with China-Africa collaboration

To address food security, China has followed a path of "supply shortage → rapid growth → excessive application → optimized fertilization". Under conditions of excessive nutrient application in farmland, China's improved nutrient management was implemented in three steps: First, reduce fertilizer use while increasing efficiency by adopting soil testing and formula fertilization technology, combined with cultivation management measures, to optimize nutrient input while achieving increased and stable yields (STP1); Second, increase production and efficiency by cultivating healthy soil to enhance its inherent fertility levels, and combine comprehensive nutrient resource management technologies to achieve increased production and efficiency (STP2); Third, achieve high yields and efficiency by integrating superior varieties, methods, and technologies based on the second step to further significantly increase yields (STP3).

In resource-scarce African agriculture, there is both hope and potential to avoid China's path of "pollute first, control later", and instead pursue African-specific agricultural sustainable development by effectively using local nutrient resources. To this end, the following cooperation is recommended:

Implementing "Three Pieces of Field Plots" Program in Africa

Drawing on the experience of Chinese farmers during an era of fertilizer scarcity including the full utilization of organic fertilizers, nitrogen fixation by leguminous crops, and the mixed application of organic and inorganic fertilizers such a program would encourage smallholder farmers in Africa to implement the "Three pieces of field plots" action plan. This involves dividing their land into three sections: one section for growing staple crops to address food security, one section for growing cash crops to address household income, and one section for growing nitrogen-fixing crops (such as alfalfa) to establish a self-fertilizing land management model. After one season, the plots are rotated. Each household would be encouraged to build its composting pit to compost household waste, straw, organic fertilizers, and green manure. After natural fermentation, government-subsidized chemical fertilizers would be mixed with compost in a specific ratio to create organic-inorganic fertilizers, which are then used to improve soil fertility in the plots designated for grain and cash crops[31]. After two crop seasons, while ensuring food security for smallholder farmers, this approach also increases their income, enabling them to afford basic agricultural inputs and achieve a self-sustaining cycle for their households.

Launching the "Integrated Crop-Livestock Systems" Initiative

In Africa, it is common to see fields near farmers' homes with thriving crops, while those farther away are in poor condition. The fundamental reason lies in the fact that African smallholder farmers have relatively large land holdings per household, cannot afford chemical fertilizers, and lack sufficient organic resources for soil improvement, thereby failing to fully utilize land productivity. To address this widespread issue, it is recommended to implement a "crop-livestock cycle" initiative in Africa, encouraging each household to raise, for example, five sheep, one cow, or 20 chickens (with exact numbers adjusting for farm or household size and resources). Drawing on China's experience of "pooling resources to tackle major challenges", organic waste and organic fertilizers should be returned to the fields and concentrated on a single plot of land near the household. By cultivating this land effectively, it can then drive improvements in productivity on more distant plots, achieving a gradual enhancement of land productivity. Through this approach, on one hand, soil fertility is enhanced, and on the other hand, it promotes a virtuous cycle of crop-livestock integration and household income, achieving poverty alleviation for farmers and reducing greenhouse gas emissions.

Launching a Pilot Project for Green Grain Production in Africa Based on Big Data and AI

Given the challenges faced by African smallholder farmers in improving grain yields such as the inability to promptly access technology, and ineffective understanding and application of technology in combination with the current situation where each African smallholder farmer owns a mobile phone, it may be possible to harness big data and AI to create a green food production initiative in Africa[32]. Specifically, small rapid testing laboratories (costing less than 15,000 yuan each) should be established at local agricultural extension stations across the region to conduct soil nutrient testing, establish soil nutrient deficiency indicators suitable for local conditions, and combine crop growth monitoring, nutrient monitoring, and fertilization recommendation models based on remote sensing technology (free open-source data) for crop management. Simultaneously, science and technology villages could be designated, encouraging university students from these villages to collaborate with local agricultural extension personnel to conduct farmer trials and demonstrations. Establish a "Farmers' Didi" service system (where farmers can call for assistance and experts respond promptly), and organize on-site meetings, training sessions, and short videos to achieve widespread dissemination of technology, ensuring that smallholder farmers can promptly access, understand, and apply the technology.

Conducting a "Three-step" Strategy to Promote Poverty Alleviation Among African Smallholder Farmers

African farmland has long been in a state of nutrient deficiency, leading to severe soil degradation, which in turn results in low farm productivity, low farmer incomes, and African smallholder farmers being trapped in a vicious cycle of poverty. To reverse this situation, it is recommended to implement a "three-step" action plan for African smallholder farmers to achieve poverty alleviation. The first step is to utilize all available organic resources and government-subsidized "one bag of seeds and one bag of fertilizer" to cultivate the land effectively, enhance farm productivity, and address food security issues; The second step is to introduce leguminous crops, implementing intercropping or relay cropping with staple crops like corn to increase land use efficiency. This approach ensures food supply while boosting intake of plant-based protein and improving farmers' nutritional diets; Third, each household raises one dairy cow to achieve efficient resource utilization across the entire chain from "grain cultivation—legume crop cultivation—dairy cow farming—straw feed conversion—organic fertilizer return to fields". This ensures effective grain supply while increasing farmers' dietary diversity and protein intake, and also enhances small-scale farmers' resilience to external, unstable risks.

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