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RESEARCH ARTICLE

Coping with challenges of resources, environment and climate change through agrifood system transformation: experiences from China and Africa

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KEYWORDS

Agrifood systems transition, climate change, food security, South–South cooperation

HIGHLIGHTS

- Direct and indirect impacts of climate change are evident in food production, markets, supply chains and consumption in China and Africa.
- Proactive actions are crucial to enhance efficiency, resilience and sustainability in response to challenges.
- Agrifood systems transformation can be promoted through strategic cooperation within the systems concept framework.

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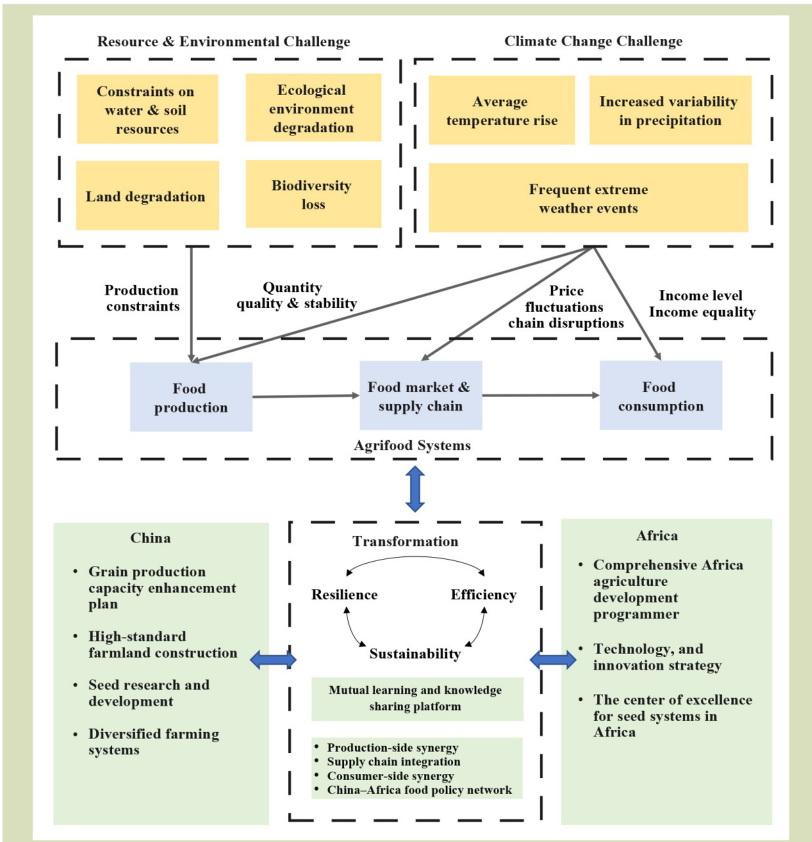
GRAPHICAL ABSTRACT



ABSTRACT

Agrifood systems in China and Africa are subject to increasing pressures due to resource limitations, environmental degradation and climate change. Both regions confront challenges such as soil degradation, water scarcity and biodiversity loss, while also experiencing the adverse impacts of climate change on agricultural productivity and food security. This paper examines these challenges and outlines strategic actions with a systems approach being taken in both regions to transform their agrifood systems. Key strategies include enhancing agricultural efficiency, strengthening resilience to climate-related shocks, and promoting sustainability through innovative practices. Also, the paper emphasizes the importance of China–Africa cooperation in climate-smart production, trade and market optimization, and sustainable diets. The role of China–Africa food policy network in supporting these efforts are also discussed. The paper concludes with a call for continued collaboration to facilitate the sustainable transformation of agrifood systems in developing countries, particularly in China and Africa, ensuring food security and resilience for the future.

1 Introduction

The agriculture and food system (agrifood system) is essential for achieving national nutrition, food security, environmental ecology, and sustainable economic and social development. The agrifood system covers all aspects of food production, storage, transportation, processing, sales, consumption and disposal (loss or waste) in the fields of agriculture (including animal husbandry), forestry, fishery and the food industry, as well as the broader economy, society and natural environment[1]. Currently, the pressure that agrifood systems place on environmental resources continues to increase, making the need for sustainable transformation urgent. Many agrifood systems worldwide have exceeded or are approaching the limits that the Earth can provide, which seriously impacts global future food production capacity[2,3]. Among these challenges, agricultural production accounts for 27% of total anthropogenic greenhouse gas emissions, 70% of freshwater use and 60% of terrestrial biodiversity loss[4,5]. In the context of the many challenges, such as resource shortage, environmental degradation and climate change, promoting the transformation toward sustainable agrifood systems has become the focus of current research.

Asia and Africa account for about 77% of the global population, and comprise 64% of the developing countries and regions. Due to weak agricultural production conditions and infrastructure, agricultural production in Asia and Africa is probably the most affected by climate change and natural disasters. Affected by the monsoon, extreme precipitation and related flood events frequently occur in Asia. Floods and other weather-related disasters cause thousands of casualties and affect millions of people every year[6]. At the same time, drought has negatively impacted agricultural production in Asia, threatening the water resource security of 29 regions, including West Asia, Central Asia and northern China[7]. In addition, climate change has hurt crop production in Africa, slowing productivity growth. Since 1961, climate change has reduced Africa's total agricultural productivity growth by 34%, more than in other regions of the world. Due to climate change, maize production in sub-Saharan Africa has decreased by an average of 5.8% and wheat production by 2.3%[8].

Although China and Africa have made considerable strides in addressing resource, environmental and climate challenges, these efforts have primarily concentrated on the production dimension, particularly through agricultural technology cooperation in areas such as hybrid rice development, irrigation systems and pest management[9,10]. However, current food security initiatives often adopt a narrow focus on boosting production, frequently overlooking the underlying systemic drivers of food system underperformance[11]. In contrast, a food systems approach offers a more comprehensive lens, accounting for the complex interconnections among production, distribution, access and consumption. This holistic perspective is especially critical and timely for analyzing the multifaceted resource and climate-related challenges that could to be addressed through China–Africa collaboration. By adopting a systems-level framework, stakeholders can better identify leverage points across the entire food system from inputs and infrastructure to market dynamics and dietary outcome[12,13].

This study makes a meaningful contribution to the agrifood systems transformation in developing countries, by adopting a systems-based approach to analyze the intersecting environmental and climate challenges impacting agrifood systems in both China and Africa. It examines shared risks to agriculture, markets and consumption under climate stress, while identifying the transformative potential of China–Africa cooperation in building more resilient, efficient and sustainable food systems. By reviewing policy efforts and innovations in both regions, the paper highlights strategic opportunities for collaboration, particularly through cooperation between developing countries, and emphasizes the importance of integrated, climate-smart responses to ensure long-term food security. Although China and Africa have made considerable strides in addressing resource, environmental and climate challenges, these efforts have primarily concentrated on the production dimension, particularly through agricultural technology cooperation in areas such as hybrid rice development, irrigation systems and pest management[9,10]. However, traditional food security initiatives often adopt a narrow focus on boosting production, frequently overlooking the underlying systemic drivers of food system underperformance[11]. In contrast, a food systems approach offers a more comprehensive lens, accounting for the complex interconnections among production, distribution, access and consumption. This holistic perspective is especially critical and timely for analyzing the multifaceted resource and climate-related challenges that could be addressed through China–Africa collaboration. By adopting a systems-level framework, stakeholders can better identify leverage points across the entire food system from inputs and infrastructure to market dynamics and dietary outcome[12,13].

This paper covers four main aspects, addressing for each the critical dimensions of the resource, environmental and climate challenges impacting agrifood systems in China and Africa, as well as the strategic opportunities for cooperation to drive system transformation.

The first examines the resource and environmental challenges affecting agrifood systems in both China and Africa. Initially, it provides an in-depth look at China's challenges, including constraints on water and soil resources, declining land quality, and broader ecological degradation. Then it examines Africa's corresponding challenges, focusing on land degradation, deforestation and biodiversity loss, being factors that critically undermine the continent's food production potential and ecosystem health.

Next the analysis focuses on the impacts of climate change on the agrifood systems of both regions. The far-reaching effects on agricultural production, markets, supply chains and consumption are discussed. This highlights the vulnerabilities of both China and Africa to climate-induced disruptions, offering a foundation for understanding the urgency of adaptive responses.

Then the paper presents the actions being taken to address the challenges of resource constraints, environmental degradation, and climate change. This outlines strategic responses across three dimensions: increasing the efficiency of resource use, enhancing system resilience to shocks, and improving long-term sustainability through policy, technological and institutional innovations.

Lastly the paper examines pathways for advancing agrifood systems transformation through strategic cooperation, with a particular emphasis on China–Africa collaboration. This underscores the role of science and technology cooperation, strengthened bilateral trade and the establishment of a China–Africa Food Policy Network as mechanisms to support mutual learning, policy alignment and inclusive development.

This structure provides a comprehensive analysis of the issues at hand while offering a roadmap for collaborative action to build resilient, sustainable and inclusive agrifood systems across China and Africa.

2 Resource and environmental challenges impacting China's and Africa's agrifood systems

Both China and Africa face shared challenges in achieving sustainable agrifood system transformation, particularly in production section, including resource shortages, soil degradation and biodiversity loss. China's agrifood system is increasingly constrained by resource and environmental pressures, primarily manifested through agricultural resource scarcity, declining land quality and ecological degradation. Meanwhile, Africa's agricultural challenges predominantly manifest as land degradation, deforestation and biodiversity depletion.

2.1 Resource and environmental challenges impacting China's agrifood system

2.1.1 Constraints on water and soil resources

The shortage of agricultural resources has become a significant constraint for sustainable agrifood systems. First, the amount of arable land in China continues to decrease. Between 2009 and 2019, the area of arable land in the country decreased by 8 Mha. Without rural land reclamation, urbanization and rural construction will further reduce the total cultivated land area by 1.3 Mha by 2050, further occupying the cultivated land area[14].

Second, there is a significant shortage of reserve resources to supplement existing cultivated land. Despite the implementation of strict farmland protection policies, such as the balance of occupation and compensation, and the balance of input and output mechanisms, the current situation remains concerning. According to national surveys and evaluations, the total area of cultivated land reserve resources now stands at 5.35 Mha, representing a decline of nearly 2 Mha compared to the previous assessment[14]. Also, the remaining land reserve resources are fragmented and scattered, and their development and utilization logistically challenging and economically costly. As a result, the established model of large-scale development and utilization is no longer suitable for exploiting fragmented reserves.

Third, agricultural water resource stress in China is intensifying. The total amount of agricultural water is insufficient, and competition from non-agricultural sectors places additional pressure on limited supplies. China's per capita share of water resources is only 2034 m^3, less than one-fourth of the world per capita water resources. The area north of the Yangtze River accounts for 64% of its land area, but the amount of water resources only accounts for 19%. Arable land is increasingly concentrated in the north, aggravating the stress in that region[15,16].

2.1.2 Decline of cultivated land quality

China has limited high-quality arable lands, and the ongoing decline in soil quality poses a major constraint on both agricultural production and environmental sustainability. Overall, the quality of arable land is not high. There is only 42 Mha of high-quality cultivated land resources, accounting for 30% of the total cultivated land area, while nearly 70% of the remaining cultivated land is of medium and low quality[17]. Due to the high-intensity use of cultivated land, the limiting factors affecting cultivated land quality in various regions have increased. From the national output analysis of 650 Mt, the unsustainable capacity of cultivated land caused by groundwater overexploitation, film residue, soil erosion and other factors accounts for about 50% of the total capacity[18].

For example, the arable layer of black land in Northeast China has become thinner, and organic matter has decreased. Continuous cropping of maize has led to a decrease in organic matter content in the surface soil of black land by 14.7%, an increase in soil bulk density by 16.3%, and a decline in essential soil fertility after 21 years of continuous cropping[19]. Agricultural water resources of the North China Plain are being severely over-exploited, leading to the formation of a major groundwater depression, often referred to as a groundwater funnel. The widespread use of mechanical wells for irrigation has resulted in unsustainable extraction rates, causing a continuous decline in groundwater levels. Recent data indicate that shallow groundwater is receding at an average annual rate of 0.46 ± 0.37 m, and deep groundwater, even more rapidly, at 1.14 ± 0.58 m. As a result, the North China Plain has become one of the three largest groundwater depletion zones in the world[20]. Soil acidification and pollution are significant issues in South China. In the past 20 years, major farmland soils in China have become significantly acidified, farmland soils experiencing varying degrees of acidification[21,22].

2.1.3 Ecological environment degradation

Agricultural production is also challenged by the degradation of the ecological environment, including the deterioration of the spatial suitability of arable land, the reduction of biodiversity and the imbalance of ecological functions.

First, the northward shift of China's arable land spatial pattern has led to a decline in arable land suitability[23]. From 2000 to 2018, China's cultivated land shifted northwest, with significant increases in the arid north and Northeast Plain. This led to a 2.6% decline in land suitability due to reduced precipitation and accumulated temperature, reflecting growing natural constraints[24].

Second, long-term and high-intensity farming has changed biodiversity, especially single intensive planting and excessive application of mineral fertilizers and synthetic pesticides, which have significantly reduced the complexity and stability of the soil food web structure. At the same time, the transformation from a natural to an artificial ecosystem has significantly reduced soil biodiversity and affected the activity and quantity of soil organisms [[25]].

Third, the use of arable land with fossil energy as the core has caused an imbalance between production and ecological functions. The traditional farming mode of planting and breeding has been replaced by a production mode that relies solely on mineral fertilizers, pesticides and synthetic pesticides. The long-term high input and low utilization rate in agriculture have led to a significant reduction in the ecological functions of arable lands, such as water circulation, water purification and filtration[26].

2.2 Resource and environmental challenges impacting Africa's agrifood systems

Africa's population is both large and rapidly growing, creating increasing demand for food, land and natural resources. By 2023, Africa will account for about 18% of the global population, and this proportion is projected to rise to 26% by 2050[27]. This demographic expansion places considerable pressure on the continent's agricultural systems and land resources. At the same time, Africa faces mounting environmental and developmental challenges, driven by a combination of natural and human-induced factors, including land degradation, deforestation and biodiversity loss. These pressures threaten the sustainability of ecosystems and underscore the urgent need for integrated land management and resilient food systems to support future generations.

2.2.1 Land degradation

Land degradation leads to a series of serious consequences, such as a decline in land productivity and deterioration of the ecological environment, which affect the sustainable development of agriculture in Africa. Land degradation worsens natural conditions, limits the application and promotion of agricultural technology, and thereby reduces the efficiency and effectiveness of agricultural production. In Northeast Africa and the Sahel region, the impact of land degradation is particularly severe, with up to 75% of the area experiencing soil erosion and degradation of soil fertility[28].

Soil erosion, including water and wind erosion, is the main manifestation of land degradation in Africa. It is estimated that a total of 8 Mha of land in East Africa is subject to medium-to-high water and wind erosion risks[29]. The situation in North Africa is not optimistic either, with about 15% of the area suffering from medium-to-high soil erosion risks caused by water and wind erosion[30]. Seawater erosion is also very serious, the backflow of seawater causes serious salinization of coastal farmland. The sea level in the Gulf of Guinea in western Africa rises by about 30 mm every 10 years, 30 mm in South Africa and 10–40 mm in northern and eastern Africa[31–33].

In addition, improper land use is leading to a general decline in soil fertility in Africa, limiting future food and feed production. This is especially true in regions with a lack of phosphate fertilizer input or unstable supply, which is the main reason for the loss of soil phosphate fertility in Africa. About 40% of soil nutrients in sub-Saharan Africa are low. Soil degradation has further exacerbated the problem of nutrient deficiency[34].

2.2.2 Deforestation

In recent years, deforestation in Africa has intensified, emerging as a major constraint on both agricultural production and environmental sustainability. Forests cover about 23% of Africa's land area and represent 16.8% of global total forest resources. These ecosystems are vital for providing essential services, including clean drinking water, energy (particularly fuelwood), traditional medicinal resources and cultural value for local communities. The ongoing loss of forest cover threatens biodiversity, disrupts ecosystem services and undermines the long-term viability of rural livelihoods and food systems across the continent[35]. More than 70% of people in sub-Saharan Africa rely on forests and woodlands for their livelihoods[36]. However, African forests are decreasing due to the expansion of cultivated land, urbanization and energy demand. Between 2010 and 2020, the annual net loss rate of African forests was between 3.9 and 4.41 Mha per year, making it the highest in the world[37]. The overall net loss rate of African forests has continued to rise, exacerbating the fragility of the ecosystem and posing greater challenges to local sustainable agricultural production.

The expansion of cultivated land in Africa overlaps with urbanization and industrialization processes, further putting pressure on forest resources and agricultural ecosystems. The conversion of African forests to cultivated land is one reason for the continuous decline in forest coverage[38]. The rapid urbanization and industrialization process also require a significant amount of land and resources. According to the moderate path analysis results of the African Shared Socioeconomic Path framework, forest land is projected to decrease by an average of 11% into construction land during 2021–2040[39].

2.2.3 Biodiversity loss

Africa is rich in terrestrial and aquatic biological resources, accounting for nearly a quarter of total natural resources globally. Due to long-term overexploitation and improper management, Africa's agricultural biodiversity is rapidly declining[40]. More than half of the world's land-related biodiversity loss occurred in Africa and Latin America[41].

Land-use change such as expansion of built-up and converting natural habitats to farmland has been a major driver of global biodiversity loss[42]. Urban clusters with the greatest threats to species due to projected expansion are predominantly located in the developing tropical regions of sub-Saharan Africa[43]. In additional, biodiversity loss of recent land-use change driven by increases in agrifood imports food trade, 75% of the land-use change impacts in Africa can be attributed to increased food exports[44].

Mining activities in Africa have a huge impact on local biodiversity[45]. Gold mines in Ghana and diamond mines in South Africa have not only directly damaged local vegetation and soil structure, but also indirectly affected the protection and restoration of agricultural biodiversity, weakening the resilience of agricultural ecosystems[46]. This makes agricultural production in Africa particularly fragile and difficult to withstand climate change and other external shocks.

In addition, overfishing is a key factor in the severe loss of marine biodiversity. For many landlocked countries in Africa, inland water capture fisheries represent for 80%–100% of total aquatic products[47]. Due to overfishing in these fisheries, the number of marine organisms has dropped significantly, leading to the destruction of the food chain and an imbalance between species. For example, the sardine population faces the serious degradation in South Africa. This is a core factor in causing the number of African penguins, which rely on sardines as their main food, to decrease by more than 65% in the past 20 years[47].

3 Challenge of climate change impacting agrifood systems of China and Africa

Climate change is the most significant risk to future food systems[48]. Direct and indirect impacts of climate change on food production, food market and supply chain and food consumer through changes in average climate, climate variability and extreme weather events (Fig. 1)[49].

3.1 Impacts on food production

Climate change leads to shifts in production patterns through changes in average temperature, precipitation, and other water and heat resources, as well as an increase in extreme weather events. This results in reduced suitability and stability, impacts on crop quality and issues such as soil degradation and pest infestations.

For China's food system, climate change impacts food production by affecting crop environments, quality and production stability. First, changes in temperature and precipitation significantly influence agriculture. Rising temperatures accelerate soil degradation by altering soil conditions, affecting nutrient retention and fertility. For example, warming and drought in North and Northeast China have promoted the decomposition of soil organic matter, accelerating nutrient loss and reducing soil organic carbon. From 1999 to 2017, global warming led to a loss of 0.29 Tg C in the Loess Plateau, with an annual decrease of 8.89 g·m^{-2} C[50]. Additionally, regional shifts in precipitation have intensified resource constraints between North and South China. Although rainfall has increased in the middle and lower Yangtze River catchment, it has decreased in the northeast, north and southwest. This has worsened droughts in the north, while increased rainfall in the south has intensified flooding, further destabilizing agricultural production[51,52].

Second, temperature changes impact crop quality and increase pest and disease risks. In Northwest China's semiarid regions, a 2–3 °C rise led to a 24.9% decrease in spring wheat starch content[53]. Rising temperatures also create favorable conditions for pests and pathogens. In North China, higher temperatures and reduced rainfall exacerbate the damage from piercing-sucking insects. Although in the Yangtze River region, pests like the rice leaf roller and brown planthopper are becoming more prevalent[54]. These changes heighten disease risks and increase the costs of pest control, also challenging traditional management strategies.

Third, climate change has increased the frequency and severity of natural disasters, destabilizing agricultural production in China. Extreme weather events, such as heavy rainfall in the Yangtze River catchment and heatwaves in East China, have become more common. Particularly at the turn of the 21st century, and frequent droughts in the southwest have worsened[55]. These events increase uncertainty in agriculture and impact crop yields. From 1981 to 2010, extreme climate events intensified temperature and water stress on double-cropping rice, causing a 6.66% reduction in early rice and a 1.82% reduction in late rice yields[56].

For Africa's food system, climate change is weakening food production in Africa, particularly through its impact on water resources and rainfall patterns. Rising temperatures reduce water availability, with a 2 °C increase potentially cutting water resources by 20%, and a 4 °C rise potentially reducing it by over 50%[55]. This exacerbates agricultural challenges, affecting soil moisture and crop growth. Additionally, changing rainfall patterns and unreliable water supply significantly reduce crop yields. About 95% of Africa's agriculture relies on rainfall, with less than 4% of land irrigated[56]. In 2023, Sudan's rainfall was below average, leading to a 25% and 50% reduction in sorghum and millet yields, respectively[57]. Also, water shortages decrease the effectiveness of fertilizers, making it harder for farmers to boost yields, especially in rainfed maize fields[58].

Extreme weather events, driven by climate change, are

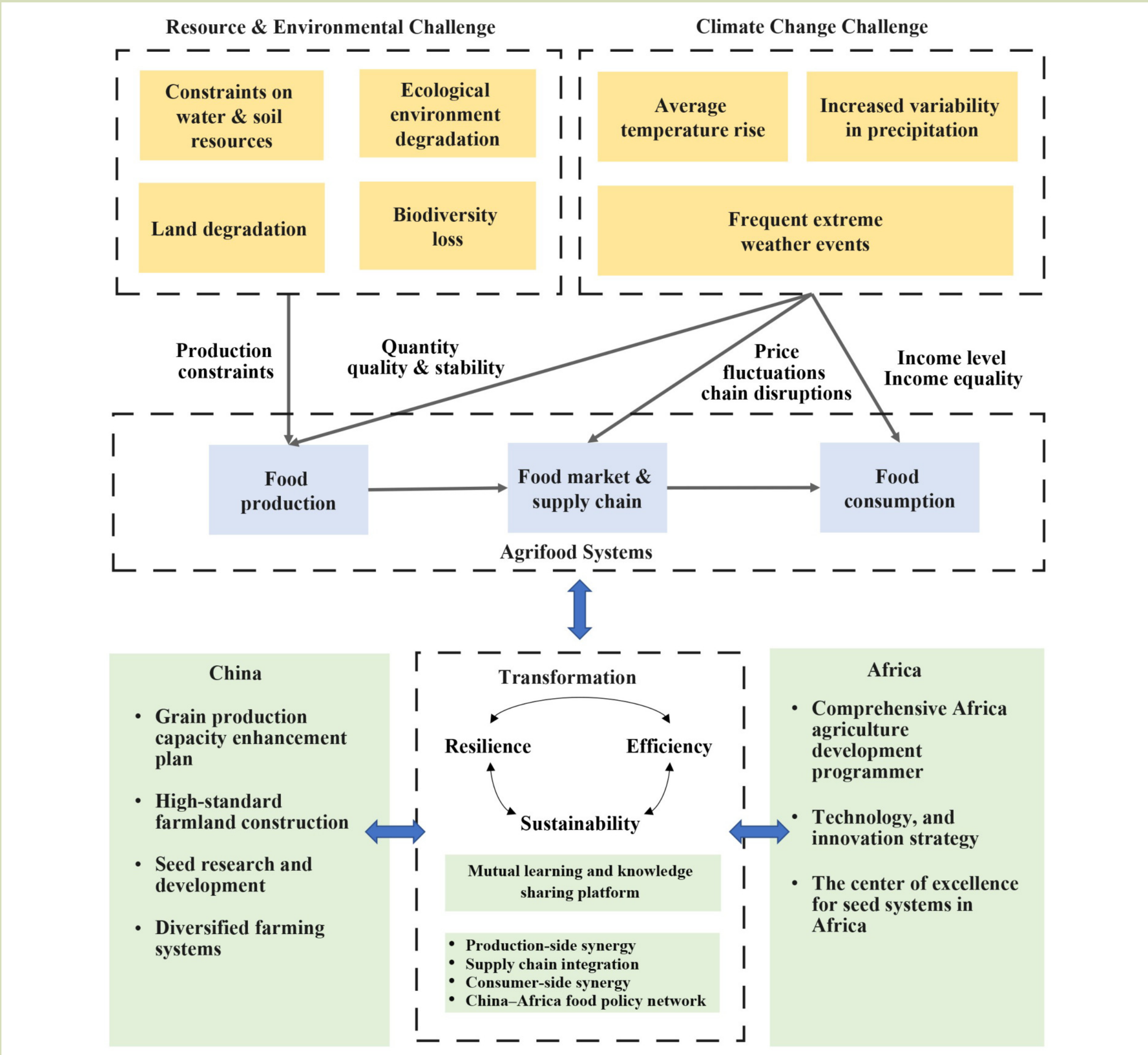


Fig. 1 Possible framework for coping with challenges of resources, environment and climate change through agrifood system transformation.

destabilizing food security in Africa[59]. Droughts and floods cause the greatest agricultural losses, with droughts accounting for 89% of the damage and floods 9%[60]. In early 2023, extreme droughts left over 20 million people in Ethiopia, Kenya and Somalia impacted by severe food insecurity[57]. Additionally, extreme weather alters disease patterns, further destabilizing agriculture. For example, Climate change scenarios predict increased aridity and desertification across vast areas of Africa, with some regions that previously fueled outbreaks likely to experience a reversal in trends[61].

3.2 Impacts on food market and supply chain

Climate change impacts food production, leading to price fluctuations in the market. It also triggers natural disasters, reduces food transportation efficiency, and disrupts agricultural trade and supply chains[49].

Climate change impacts China's food market by causing supply shortages and price increases. Under the RCP2.6 (low emission global scenario) and RCP8.5 (high emission global scenario), crop prices are expected to rise by 2030 and 2050[62]. Also, the country's transition to a low-carbon food system is subject to challenges, with early emissions reduction costs increasing market volatility[63]. China's agricultural system emits 1.09 Gt CO_2 equivalents, accounting for 9%–12% of China's total emission[64]. Despite efforts to reduce emissions, agriculture remains a major emitter due to the high number (about

200 million) of small farmers, low adoption of low-carbon technologies and high dissemination costs[65].

Climate change amplifies Africa's food market vulnerability by weakening its ability to secure food through global trade, reducing agricultural investment, and impacting long-term food supply and prices[60]. Africa's high reliance on food imports (52.4% in North Africa, 16.2%–31.5% elsewhere) makes it vulnerable, especially with growing food demand due to population growth[66]. Climate change also disrupts global trade, raising costs and uncertainty, which further risks Africa's food supply. Additionally, frequent extreme weather events increase agricultural uncertainty and discourage investment. In 2022, Africa had 80 climate-related disasters, resulting in over 8.5 billion USD in losses[57]. Climate change costs Africa 5%–15% of its GDP annually, and limited government funding for agricultural development and climate resilience exacerbates these challenges[67].

3.3 Impacts on food consumers

Climate change affects the livelihoods and incomes of agricultural populations, especially in regions heavily reliant on farming and single crops. Reduced income harms diet quality and food diversity. Extreme weather events, like heatwaves and wildfires, increase non-communicable diseases and worsen public health crises.

In China, climate change impacts farmers' incomes, especially in ecologically vulnerable areas, widening income inequality. Increased extreme rainfall reduces income and exacerbates disparities[68]. Additionally, climate change alters crop conditions, posing hidden risks to nutrition. For example, higher CO_2 levels boost rice photosynthesis but reduce its protein, amino acid and mineral content[69].

In Africa, climate change increases extreme events that threaten water safety, food security and health, leading to higher rates of infectious and non-communicable diseases. It also alters the spread of bacteria, viruses and parasites, raising the risk of food and water contamination and increasing waterborne and foodborne diseases[70]. Additionally, climate-induced food price hikes reduce the ability of vulnerable groups, such as the poor, to access food, heightening the risk of food shortages and malnutrition. In 2021, 77.5% of Africa's population could not afford a healthy diet, well above the global average of 42.2%, worsening the continent's food security crisis[71].

4 Actions for coping with challenges of resource, environment and climate change

4.1 Increase efficiency

To build a high-yield and efficient agricultural system, China is focusing on improving land productivity, labor productivity, and total factor productivity as key levers to increase farmers' incomes (Table 1). As part of this effort, the government has launched the Grain Production Capacity Enhancement Plan (2024–2030), which aims to boost annual grain output by more than 50 Mt and stabilize total production capacity at 700 Mt by 2030. This initiative underscores China's commitment to ensuring food security while enhancing the economic viability of its agricultural sector.

The Chinese government has prioritized high-standard farmland construction to ensure drought and flood resistance, water efficiency, high yields and environmental sustainability. The goal is to create staple food fields capable of producing to meet growing food demands and ensure national food security. By the end of 2022, China had built 66.7 Mha of high-standard farmland, ensuring a stable grain production capacity of over

Table 1 Actions for coping with challenges of resource environment and climate changes

Catagory	Actions in China	Actions in Africa
Efficiency	Grain production capacity enhancement plan High-standard farmland construction	Comprehensive Africa agriculture development programmer Technology, and innovation strategy
Resilience	Seed research and development Diversified farming systems High-standard farmland construction	Africa seed system excellence center Women-led agribusinesses in Africa Comprehensive Africa agriculture development programmer
Sustainability	Crop rotation and fallow system Black soil protection program Zero-growth policy for fertilizers and pesticides Plan for low-carbon agricultural development	The African soil program Great green wall initiative Comprehensive Africa agriculture development programmer

500 Mt. By 2030, the target is to add 80 Mha, supporting a stable grain capacity of over 600 Mt.

The African Union and individual countries are enhancing agricultural food systems through initiatives such as Agenda 2063[72] and the Comprehensive Africa Agriculture Development Programmer (CAADP)[73]. The CAADP aims to accelerate economic growth by developing agriculture, with African governments committing at least 10% of their budgets to agriculture and rural development, targeting an annual growth rate of 6%[73]. This will reduce poverty and malnutrition, boost productivity and promote sustainable agricultural practices. The African Science, Technology and Innovation Strategy prioritizes science and innovation to drive socioeconomic development, focusing on agriculture, the environment and water resources[74]. By fostering a knowledge-based economy, this key initiative aims to eliminate hunger, ensure food security, and control diseases as part of Africa's development transformation.

4.2 Enhance resilience

A resilient system is the ability to quickly recover after shocks[75]. Strengthening food system resilience helps individuals, communities and nations prevent, prepare for, respond to and recover from impacts including natural disasters, conflicts, climate change and pandemics, ultimately fostering greater prosperity[76].

China's agricultural food system focuses on seed R&D, utilizing platforms such as the South Breeding Silicon Valley in Hainan to create resilient, high-yield cultivars. Over 70% of new crop and 80% of rice cultivars are bred here, including innovations such as hybrid rice and insect-resistant cotton[77]. China also promotes diversified planting to enhance biodiversity, expand gene pools, and improve resilience to climate change, while reducing supply chain risks. The Soybean Revitalization Plan encourages techniques including ridge planting and maize-soybean strip cropping to boost productivity[78]. Additionally, high-standard farmland construction prioritizes post-disaster recovery, with plans to assess damage and provide rebuilding programs and financial support.

In Africa, agricultural food system resilience is strengthened by organizations including Alliance for a Green Revolution in Africa (AGRA)[79]. AGRA focuses on sustainable agriculture, seed systems, inclusive markets, and policy advocacy. It developed the Seed System Assessment Tool to analyze seed systems in several African countries and launched the Africa Seed System Excellence Center to support the development of modern, resilient seed systems[79].

AGRA collaborates on projects, for example, a 12 million USD soil mapping initiative in West Africa, and promotes regenerative agriculture, enhancing resilience for farmers and the environment. It also supports agroforestry, benefiting 210,000 smallholder farmers[79]. In East Africa, AGRA stimulates job opportunities in rice processing and local rice trade, encouraging the food processing sector as a way to build resilient markets. Additionally, AGRA supports Value4Her, a platform connecting women to markets and finance to increase their agricultural participation[80]. The CAADP also supports member countries in developing strategies for natural disaster response, establishing early warning and response systems and building social safety nets to enhance resilience to climate change.

4.3 Improve sustainability

Sustainability focuses on long-term development and environmental impact, ensuring current needs are met without compromising the ability of future generations to meet theirs. To address land degradation and ecological issues from intensive farming, China has implemented key policies to promote sustainable agriculture and ecological restoration.

The government launched a crop rotation and fallow system in 2016 to combat groundwater depletion and soil fertility loss. This rotation system, applied in regions including North and Northeast China, has led to ecological improvements, with over 20 billion yuan invested over 7 years. Second, the Black Soil Protection Program (2021–2025) aims to restore the declining black soil layer in Northeast China by improving soil quality through fertilization, soil improvement, and erosion control[81]. By 2025, soil organic matter is expected to increase by over 10%, preventing further degradation[81].

To address agricultural non-point source pollution, China has promoted a zero-growth policy for fertilizers and pesticides since 2015, focusing on reducing fertilizer use and improving efficiency. By 2024, fertilizer use has decreased by 10 Mt compared to 2015, and the fertilizer use rates in maize, rice and wheat have increased to 42.6%, a 6.4% rise. Finally, The Ministry of Agriculture and Rural Affairs of China issued a plan for low-carbon agricultural development, promoting emission reductions, carbon sequestration, and renewable energy. These measures support China's carbon neutrality goals.

Africa's agrifood system are prioritizing sustainability. The African Soil Program (Afrisoils) aims to boost soil productivity by 30% and reduce soil degradation by 25% in 47 countries over the next decade, improving food and nutrition security[82]. The Great Green Wall project of the African Union, launched in 2007, combats desertification and restores the ecology of the Sahel region. It focuses on cross-border reforestation to halt the Sahara's southward spread[83]. Since its launch, the project has significantly increased vegetation cover, particularly in Ethiopia (15%), and created about 1.5 million jobs, demonstrating its environmental and socioeconomic benefits[83].

5 Advancing agrifood systems transformation through strategic cooperation

China and Africa, accounting roughly for one-third of the global population, face common challenges as developing regions navigating the complexities of a globalized world. Over the years, their deepening cooperation has not only supported mutual development but has also played a significant role in advancing the broader modernization of the developing countries. The complementarities between their respective strengths and needs have fostered synergetic partnerships through strategic cooperation by fostering climate-smart production, enhancing trade and market collaboration, and promoting sustainable diets, which enable both sides to collaboratively address pressing resource, environmental and climate challenges (Table 2).

5.1 Production-side synergy: boost nature-positive and climate-smart production

China and Africa face common challenges such as soil degradation, water scarcity and climate-related disruptions to their food systems. However, these shared issues present an opportunity for cooperation. Tackling resource and climate challenges through nature-positive production, climate services, and climate-smart agriculture training can boost efficiency, resilience and agrifood sustainability in both regions.

First, technology sharing and cooperation between China and Africa have the potential to significantly enhance the efficiency of agrifood systems, reduce postharvest losses and waste, and ultimately increase the overall value and returns across the entire food value chains[84]. Specifically, the innovation of win–win technologies can address the current challenges impacting both regions, such as resource shortages, climate threats and smallholder-based food systems. These innovations can bring new opportunities to the entire value chain and help transform agricultural food systems through multi-objective synergy.

Second, natural resource management can promote positive natural production. For example, spreading perennial and hybrid rice cultivars boosts efficiency and reduces labor. Additionally, sharing technologies, such as conservation tillage, crop rotation, fallowing and straw return, helps prevent land degradation and promotes the sustainable use of resources.

Third, climate information services are vital for managing climate risks and strengthening smallholder resilience. For example, Ethiopia-China collaboration led to the launch of Ethiopia's first satellite, ETRSS-1, which supports climate services. This initiative has helped 87 agricultural extension agents access seasonal weather forecasts and climate advisories, improving their adaptability to both short and long rainy seasons[85].

Last but not least, promoting climate-smart knowledge and

Table 2 Cooperation to address challenges and facilitate the agrifood systems transition

Cooperation strategy	Efficiency	Resilience	Sustainability
Production-side synergy: boost nature-positive and climate-smart production	Win–win technology promotion	Climate information services cooperation Climate-smart agriculture training	Natural resource management
Supply chain integration: trade and market optimization	Strengthening investment in agricultural food systems	Diverse food trade networks and technology sharing channels	Increased private sector investment in agriculture
Consumer-side synergy: access to healthy and sustainable diets	Agricultural tourism model	Farm-to-table initiatives	Carbon footprint labels
China–Africa food policy network establishment	Supportive digital policies Financial services	Strategic food reserves Technology empowerment for vulnerable and marginalized groups	Strengthening trilateral cooperation Clear, transparent and fact-based communication channels

innovative technologies is essential to adapt to and mitigate these challenges in Africa and China. Key actions include training smallholders, providing on-site guidance and sharing climate-smart practices. For example, Science and Technology Backyard (STB) program of China Agricultural University offers on-site services and supports urban-rural integration[86]. By 2023, this program had been established in 1048 locations across 31 Chinese provinces covered over 200 agricultural products, with the model expanding to African countries.

5.2 Supply chain integration: trade and market optimization

Stabilizing international trade and strengthening agricultural supply chain cooperation are key issues for the future of China–Africa relations. China has been Africa's largest trading partner for 15 consecutive years, and the share of China–Africa trade in Africa's total external trade has steadily increased. Strengthening China–Africa food trade cooperation helps African countries balance trade deficits while enabling China to import a diverse range of food products from Africa.

China–Africa trade liberalization can boost bilateral economic cooperation, improve business operations, and enhance the sustainability of agricultural food systems. Currently, 16 African countries have a trade surplus in agricultural products with China, while 33 have a deficit. The structural quantitative model predicts that signing a China–Africa Free Trade Agreement could increase overall food trade between Africa and China by 0.01%–13.4%[87].

Investment in agricultural food systems should be strengthened. Since 2003, China's annual foreign direct investment in Africa has grown significantly, from 74.8 million to 4.2 billion USD by 2020, with total stock increasing nearly hundredfold[88]. However, past investments were mainly in construction and mining, so future investments should focus on food system transformation.

Private sector involvement should be strengthened. In past agricultural cooperation, governments and state-owned enterprises have led in aid and investment. State-owned enterprises often lack flexibility, hindering connections with local markets[89]. Private companies, particularly those with successful operations in Africa, should be integrated into business operations to make a more significant contribution to technology transfer and promotion. Increased private investment can sustainable technical assistance and digital platforms, benefiting smallholders through contracts and employment opportunities.

5.3 Consumer-side synergy: access to healthy and sustainable diets

Consumer-side synergy offers a critical pathway to align consumption patterns with agrifood system sustainability, addressing resource constraints, environmental degradation and climate risks. By introducing measures including carbon footprint labels and farm-to-table, empowers consumers to become active contributors to food system resilience through healthier and more sustainable choices.

It is available to promote farm-to-table initiatives integrating local production with consumer demand. For example, China's agricultural tourism model combines food consumption with tourism, boosting local GDP[90]. In Africa, similar models such as Senegal's agritourism projects can diversify rural incomes[91].

Also, it introduces carbon footprint labels on food products, using China's low-carbon agricultural metrics[92]. For example, African coffee producers can showcase carbon-friendly practices, guiding Chinese consumers to choose products with lower emissions. This aligns with global findings that dietary shifts can cut food system emissions by 20%–30%[93].

5.4 Establishing a China–Africa food policy network

A high-level dialog mechanism between China and Africa should be established to foster collaboration in building resilient food systems. For example, the 2024 China–Africa Cooperation Forum Summit adopted the Beijing Declaration and the Beijing Action Plan (2025–2027) emphasizing agricultural modernization, energy use and development cooperation[94]. Working groups should be created to address key policy issues such as food security, climate adaptation, poverty reduction, and climate financing, focusing on areas such as digital infrastructure, inclusive financial systems for smallholders and strategic food reserves. The Food Policy Network and Policy Innovation are essential foundations for China–Africa collaboration in the transition of Africa's food systems[94].

China and Africa should also expand bilateral and multilateral cooperation in agrifood system. This includes engaging with other developing countries, development agencies and NGOs to maximize the impact of agrifood system transition. Additionally, to provide objective and reliable evidence for spreading and addressing international public opinion, international participation, especially from third-party organizations, should be encouraged to assess the environmental impact of China–Africa agricultural projects. That is crucial to establish clear, transparent and fact-based communication channels.

6 Conclusions

The transformation of agrifood systems in China and Africa is essential to addressing the interconnected challenges of resource scarcity, environmental degradation and climate change. Despite these shared challenges, the growing partnership between China and Africa presents a unique opportunity for joint progress. This paper applies a systems approach to highlight the need for enhanced China–Africa cooperation in tackling interconnected environmental and climate challenges in agrifood systems.

To drive the transformation of agrifood systems, it is essential to foster strategic China–Africa cooperation grounded in climate-smart production, efficient trade and market integration, and the promotion of sustainable and nutritious diets. This collaborative approach is critical to tackling pressing challenges such as soil degradation and climate vulnerability. At the heart of this transformation lies a commitment to both bilateral and multilateral partnerships, enabled through strategic instruments such as the proposed China–Africa Free Trade Agreement and initiatives centered on mutual technology transfer and innovation (win–win technology promotion). Also, the creation of a high-level dialog platform and a dedicated China–Africa Food Policy Network would foster continuous knowledge exchange, co-design of inclusive policies, and alignment of agricultural strategies. By investing in these pivotal areas, China and Africa cannot only advance their shared development objectives but also emerge as global leaders in shaping resilient, equitable and sustainable agrifood systems for the 21st century.

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Compliance with ethics guidelines

Ming Lei, Ting Meng, Zhiyao Yang, Jingjing Shan, and Issa Ouedraogo declare that they have no conflicts of interest or financial conflicts to disclose. This article does not contain any studies with human or animal subjects performed by any of the authors.

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