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DISSERTATION

INTERNATIONALIZATION STRATEGY OF CHINESE AGRICULTURE: FOSTERING SUSTAINABLE DEVELOPMENT AND PROMOTING GLOBAL FOOD SECURITY

specialty 051 – Economics
(Field of study 05 – Social and Behavioural Sciences)

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The dissertation contains the results of own research. The use of ideas, results, and texts of other authors have references to the relevant source.

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АНОТАЦІЯ

Ду Вей. Стратегія інтернаціоналізації сільського господарства Китаю: стимулювання сталого розвитку та сприяння глобальній продовольчій безпеці. – Кваліфікаційна наукова праця на правах рукопису.

Дисертація на здобуття ступеня доктора філософії за спеціальністю 051 – Економіка. – Західноукраїнський національний університет, Тернопіль, 2025.

Метою дисертації є поглиблення теоретичних засад стратегії інтернаціоналізації аграрного сектору Китаю відповідно до принципів сталого розвитку та сприяння глобальній продовольчій безпеці.

Розкрито онтологію інтернаціоналізації сільського господарства як процес інтеграції національного аграрного сектору в глобальні економічні, торговельні та інституційні системи з метою розширення доступу до зовнішніх ринків, трансферу аграрних технологій, оптимізації ланцюгів постачання та залучення інвестицій, що у взаємозв'язку зі стратегіями сталого розвитку сприяє зміцненню глобальної продовольчої безпеки, екологічній збалансованості виробництва та соціально-економічній стабільності сільських територій.

Систематизовано теоретичні моделі аграрного прогресу та інтернаціоналізації, з акцентом на такі ключові аспекти: технологічні інновації, ефективність використання ресурсів, екологічну сталість, економічну оптимізацію та політичну підтримку. Проаналізовано класичні та сучасні теорії інтернаціоналізації для оцінки можливостей їх адаптації до сучасних реалій аграрного сектору Китаю.

Прослідковано еволюцію підходів до глобального аграрного розвитку – від натурального господарства та індустріальної доби, через механізацію і монокультуру, до технологічного прориву «зеленої революції», а далі – до стратегії сталої інтенсифікації, узгодженої з Цілями сталого розвитку. Проаналізовано національні стратегії США, ЄС, Японії та Китаю, що демонструють різні підходи та унікальну роль кожної країни у досягненні аграрної інтернаціоналізації, розвитку та продовольчої безпеки – контроль над ланцюгами постачання, екологічні

стандарти, експорт продукції з високою доданою вартістю та інтеграцію до глобальної торгівлі.

Проведено кластерний аналіз провінцій Китаю з метою виявлення регіональних відмінностей в аграрній та економічній діяльності із застосуванням ієрархічного кластерного аналізу за методом Варда та метриками евклідової відстані. Виділено окремі групи провінцій за ключовими показниками: ВРП регіонів, розподіл міського і сільського населення, обсяги аграрного виробництва та участь у зовнішній торгівлі. Виявлено суттєві відмінності – від розвинених економічних центрів, як-от Гуандун і Шанхай, із високою торговельною активністю та низькою часткою аграрного виробництва, до регіонів, орієнтованих на сільське господарство, таких як Хейлунцзян і Хенань. Також виокремлено провінції зі спеціалізованими аграрними секторами – тваринництвом у Внутрішній Монголії та рибальством у Фуцзяні. Отримані результати підкреслюють важливість регіональної спеціалізації та структурної оптимізації для подолання економічних і аграрних викликів, а також дають уявлення про динаміку аграрної географії Китаю.

Виявлено основні тенденції міжнародної торгівлі Китаю сільськогосподарською продукцією, які демонструють динамічні зміни у структурах імпорту та експорту, обумовлені внутрішнім попитом, глобальними ринковими коливаннями та стратегічною політикою. Диверсифікація джерел постачання, зокрема активна торгова співпраця з Україною, є важливим елементом аграрної стратегії Китаю. Поставки Україною таких товарів, як кукурудза, соя, соняшникова олія та пшениця, відіграють важливу роль у забезпеченні продовольчої безпеки та стабілізації цін на китайському ринку. Двостороннє співробітництво в аграрних інвестиціях, технологіях та сталих практиках, включаючи точне землеробство та екологічне господарювання, сприяє модернізації аграрного сектору обох країн. Ці партнерства підкреслюють залежність Китаю від диверсифікованих глобальних ланцюгів постачання та його відданість міжнародній аграрній співпраці заради сталого розвитку.

Системно окреслено роль Китаю в міжнародному трансфері капіталу, що демонструє його значний вплив на розвиток світового сільського господарства та продовольчу безпеку. Завдяки таким інструментам, як прямі іноземні інвестиції, експорт технологій, розбудова торговельних мереж і державно-приватні партнерства, Китай активно сприяє модернізації й сталому зростанню сільського господарства в різних регіонах. Ключові ініціативи, як «Один пояс – один шлях», підтримують розвиток інфраструктури, підвищення продуктивності та впровадження передових технологій у країнах Африки, Південно-Східної Азії та Латинської Америки. Незважаючи на такі виклики, як політична нестабільність, проблеми з правами на землю та ринкові ризики, китайські інвестиції свідчать про сприяння оптимізації ресурсів, екологічній сталості та міжнародній співпраці.

Детерміновано глобальні виклики розвитку та сталості сільського господарства, включаючи зростання населення, обмеженість ресурсів, зміну клімату, нестачу води та деградацію ґрунтів, з метою показати їх вплив на продовольчу безпеку та екологічний баланс. Подолання цих викликів вимагає глобальних зусиль у впровадженні точного землеробства, біотехнологій та міжнародного співробітництва задля забезпечення ресурсоефективних і сталих аграрних практик. Ключові диспропорції, такі як нерівномірний розподіл ресурсів, стан ґрунтів і розвиток інфраструктури, додатково підкреслюють потребу в інноваційних стратегіях і колективному управлінні для сталого аграрного перетворення та детермінують сучасне середовище стратегії інтернаціоналізації сільського господарства Китаю.

Визначено пріоритетні напрями аграрної трансформації Китаю як передумови реалізації стратегії аграрної інтернаціоналізації країни у п’яти ключових сферах: (1) розвиток науки, технологій та інновацій для підвищення продуктивності шляхом впровадження розумного землеробства, генетичного удосконалення та точного фермерства; (2) сприяння сталому аграрному розвитку через еко-землеробство, циркулярні системи та низьковуглецеві технології; (3) посилення фінансової підтримки шляхом розвитку страхування, доступу до кредитування та створення галузевих фондів; (4) реформа земельних відносин і бізнес-моделей через правові зміни, розвиток сімейних ферм та кооперативів; (5) модернізація аграрного виробничого ланцюга шляхом глибокої переробки, розвитку брендів, уніфікації експортних стандартів і розвитку транскордонної електронної торгівлі для підвищення доданої вартості та конкурентоспроможності на глобальному рівні.

Розроблено стратегію інтернаціоналізації сільського господарства Китаю як комплексну рамкову модель для зміцнення глобальної продовольчої безпеки, просування сталого сільського господарства, активізації міжнародної торгівлі та інвестицій, прискорення трансферу технологій і підтримки розвитку сільських територій. Вона базується на принципах державного управління, інвестиційної активності підприємств та технічного співробітництва, охоплюючи політичне планування, інфраструктурний розвиток і міжнародну взаємодію. Стратегія структурована за п’ятьма основними напрямами: диверсифікація аграрної торгівлі, просування іноземних аграрних інвестицій (особливо в Африці, Латинській Америці та Південно-Східній Азії), стимулювання трансферу технологій та інновацій, розвиток аграрної інфраструктури і логістики, а також координація міжнародної політики через співпрацю з такими глобальними інституціями, як ФАО, і інтеграцію з ініціативами на кшталт «Один пояс – один шлях». Такий цілісний підхід відображає прагнення Китаю відігравати активну роль у формуванні майбутнього світового сільського господарства.

Ключові слова: сільське господарство, інтернаціоналізація, міжнародна співпраця, сталий розвиток, продовольча безпека, зміна клімату, аграрний ринок, міжнародна торгівля, міжнародна економіка, прямі іноземні інвестиції, зернова ініціатива, сільські території, регіональний розвиток, Китай.

ANNOTATION

Du Wei. Internationalization strategy of Chinese agriculture: fostering sustainable development and promoting global food security. – Qualification scientific work in the form of a manuscript.

Dissertation for the degree of Doctor of Philosophy in the specialty 051 – "Economics". – West Ukrainian National University, Ternopil, 2025.

The goal of the dissertation is to deepen the theoretical foundations of the strategy of internationalization of China's agricultural sector in accordance with the principles of sustainable development and promotion of global food security.

The ontology of agricultural internationalization is revealed as a process of integration of the national agricultural sector into global economic, trade and institutional systems in order to expand access to external markets, transfer of agricultural technologies, optimize supply chains and attract investments, which, in conjunction with sustainable development strategies, contributes to strengthening global food security, ecological balance of production and socio-economic stability of rural areas.

Theoretical models of agricultural progress and internationalization is systemized, emphasizing key dimensions such as technological innovation, resource efficiency, ecological sustainability, economic optimization, and policy support. Classical and modern theories of internationalization are analyzed to assess the possibilities of their adaptation to the modern realities of the agricultural sector in China.

Global agricultural development strategies Progression is tracked and categorized into stages, from subsistence farming in the pre-industrial era, to mechanization and monoculture during the Industrial Revolution, to the Green Revolution's technological advances, followed by sustainable intensification and alignment with the Sustainable Development Goals. The national strategies of typical agriculturally developed countries and regions, and China are examined, emphasizing varied methods like supply chain management, ecological agricultural norms, high-value product exports, and integration into global trade networks. These approaches

showcase each country's distinct contribution to worldwide agricultural progress and food security.

The cluster analysis of Chinese provinces is conducted to examine regional disparities in agricultural and economic activities, employing hierarchical clustering with the Ward’s linkage method and Euclidean distance metrics. The study identifies distinct groups of provinces based on key indicators such as regional GDP, urban and rural population distribution, agrarian output, and trade participation. The results reveal significant variations, ranging from highly developed economic centers like Guangdong and Shanghai, characterized by strong trade activity and low agrarian output, to agriculture-dominant regions such as Heilongjiang and Henan, which exhibit high levels of agricultural production relative to GDP. Additionally, provinces with specialized agricultural sectors, such as animal husbandry in Inner Mongolia and fisheries in Fujian, forms distinct subgroups, highlighting the diversity in regional agricultural patterns. This comprehensive analysis underscores the importance of regional specialization and structural optimization in addressing the economic and agricultural challenges faced by different areas, while offering insights into the dynamics of China's agricultural geography and its implications for policy and development.

The patterns of China's international trade in agricultural products are identified, showcasing dynamic developments in import and export patterns shaped by domestic demand, global market fluctuations, and strategic policies. Diversification in supply sources, including robust trade cooperation with Ukraine, has been integral to China's agricultural strategy. Ukraine has played a pivotal role in stabilizing the market prices and ensuring food security in China by providing key commodities like corn, soybeans and sunflower oil. Furthermore, bilateral collaborations in areas like agricultural investment, technology exchange, and sustainable practices have strengthened the relationship, with initiatives like precision agriculture and ecological farming driving modernization efforts in both nations. These collaborations highlight China's dependence on varied global supply chains and its dedication to promoting international agricultural cooperation.

The international transfer of capital in China is systematically determined, demonstrating its significant impact on global agricultural development and food security. Foreign direct investment, technology exports, trade networking, and public-private partnerships, China has actively promoted the modernization and sustainable growth of agriculture in various regions. Major programs, such as BRI, are promoting agricultural infrastructure, enhancing productivity, encouraging the integration of advanced technologies in nations throughout Africa, Southeast Asia, and Latin America. Despite challenges such as policy instability, land ownership issues, and market risks, China's investments have showcased a commitment to resource optimization, ecological sustainability, and international cooperation.

Global challenges in agricultural development and sustainability, including population growth, resource constraints, climate change, water scarcity, and soil degradation, are systematically analyzed to highlight their impact on food security and ecological balance. Addressing these challenges requires global efforts such as precision agriculture, biotechnology, and international cooperation to ensure resource-efficient, sustainable agricultural practices. Key imbalances, such as uneven resource distribution, soil conditions, and infrastructure development, further highlight the need for innovative strategies and collective governance for sustainable agricultural transformation and determine the current environment for China’s agricultural internationalization strategy.

Priority areas for China’s agricultural transformation are identified as prerequisites for implementing the country’s agricultural internationalization strategy in five key areas. These include (1) the advancement of science, technology, and innovation to enhance productivity through smart agriculture, genetic improvement, and precision farming; (2) the promotion of sustainable agricultural development via eco-agriculture, circular systems, and low-carbon practices; (3) the strengthening of financial support mechanisms such as agricultural insurance, credit access, and industrial funds to support modernization and internationalization; (4) The evolution of rural land utilization and the development of novel business approaches through legal adjustments, the expansion of family-operated farms, and the growth in agricultural cooperatives; and (5) the upgrading of agricultural industry chains by promoting deep-processing, brand cultivation, standard convergence for exports, and cross-border e-commerce to boost value-added production and global competitiveness.

China's agricultural internationalization strategy is elaborated as a comprehensive framework to enhance global food security, promote sustainable agriculture, stimulate international trade and investment, facilitate technological transfer, and support rural development. Built on the principles of government leadership, enterprise-driven investment, and technical cooperation, the strategy encompasses policy formulation, infrastructure development, and international engagement. It is structured around five key pillars: diversification of agricultural trade, promotion of overseas agricultural investment – advancement of technology transfer and innovation, improvement of agricultural infrastructure and logistics, and coordination of international policies through collaboration with global institutions such as the FAO and integration with initiatives like the Belt and Road. This comprehensive method demonstrates China's aspiration to take on a pioneering role in defining the future of worldwide agriculture.

Keywords: agriculture, internationalization, international cooperation, agricultural strategy, sustainable development, food security, climate change, agricultural market, international trade, international economy, foreign direct investment, grain initiative, rural areas, regional development, China.

СПИСОК ОПУБЛІКОВАНИХ ПРАЦЬ ЗА ТЕМОЮ ДИСЕРТАЦІЇ

Наукові праці, в яких опубліковані основні наукові результати дисертації:

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Ду В. Фактори впливу та перспективи китайських зовнішніх прямих іноземних інвестицій в сільське господарство. *Вчені записки*. 2024. № 36(3). С. 272-280. https://doi.org/10.33111/vz_kneu.36.24.03.23.159.165

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CONTENT

INTRODUCTION

Relevance of the theme. In the contemporary world, worldwide issues such as increasing population, changing climate, scarce resources, and environmental deterioration are growing in importance. Among these concerns, maintaining food security and encouraging sustainable agricultural advancement have garnered considerable global attention. These challenges are intertwined and complicated, and it is urgent to adopt systematic and holistic coping strategies. This paper focuses on the implementation path of China's agricultural "going out" strategy and its far-reaching impact on the global food security pattern and sustainable agricultural development, which provides an important reference for promoting the UN's sustainable development agenda in 2030, especially for eradicating hunger (SDG 2) and promoting sustainable consumption and production mode (SDG 12). This research not only aligns with the strategic objectives of the FAO but also fosters collaboration with the agricultural cooperation programs. It offers fresh perspectives on balancing the complex interplay among agricultural economic growth, environmental conservation, and social equity.

China's agricultural outbound direct investment reached USD 3.3 billion in 2023 with projects across Asia, Africa, and Latin America, reflecting its growing influence in shaping transnational agricultural value chains. Furthermore, China accounted for over 18% of global agricultural output and was the largest importer of agricultural products, including soybeans, grains, and meat, underscoring its dual role as both a producer and consumer on the global stage. Meanwhile, more than 820 million people worldwide still suffer from hunger, highlighting the urgency of improving global food distribution systems – an area where China's internationalization strategy can contribute meaningfully. Being a major player in the global agricultural product supply chain and also one of the largest consumer markets, China is reshaping the pattern of the world food system with its international cooperation framework. Exploring China's strategic layout in the agricultural sector holds great importance, including scientific and technological innovation system, international trade policy, cross-border investment model and green agricultural development path, to comprehensively evaluate its impact on ensuring global food supply, promoting ecological sustainability and promoting economic prosperity of countries with different development levels.

In contemporary research circles, issues such as agricultural sustainable development, transnational agricultural cooperation and world food security system have aroused extensive research attention. The aspects of internationalization of agricultural regions and their sustainability are highlighted in the papers of O. Borysiak, N. Horin, L. Howard, V. Kuryliak, I. Lishchynskyy, M. Lyzun, D. Lopez, V. Panchenko, M. Shkurat, J. Smith O. Sokhatska, H. Willer, I. Zvarych, R. Zvarych. Agricultural modernisation and poverty reduction in China are researched in the papers of Z. Mei, Z. Qian, N. Salidjanova, L. Sheng, L. Shu, W. Ting, Z. Xiaoling, Z. Xin, L. Yan, X. Yanling. International cooperation and the Belt and Road Initiative to support global food security balance is considered in the papers of Y. Chen, Y. Cui, T. Huang, J. Liu, S. Li, K. Morton, W. Thompson, M. Yastrubskyi, L. Ukrainets, H. Wang, W. Zhang, Y. Zhao.

However, the issues of internationalization at China's agricultural segment under the current geopolitical challenges require a more precise focus to foster the investigations of sustainable development and promotion of global food security.

Connection of work with scientific programs, plans, topics. This study made a contribution to scientific researches of the West Ukrainian National University, in particular: fundamental state budget funding research “Regional Security Model: Economic and Technical Aspects of Sustainable Development and Civil Protection in Wartime” (state registration number 0124U000063); research theme “Geoeconomic and civilizational challenges of the development of the global economy” (state registration number 0121U111077); international project “Regional Integration: European Benchmark under the Challenges of Global Fragmentation” (Erasmus+ Jean Monnet Module 101048216 – REFRAG – ERASMUS-JMO-2021-HEI-TCH-RSCH), business funding research “Modern mainstreams of global development: economic, environmental, social and military challenges” (contract No ME-30-2022 dated 13.06.2022).

The purpose of this study is to conduct a theoretical systematization and comprehensive analysis of the internationalization processes within China's agricultural sector, offering strategic recommendations to enhance its sustainability and make contributions to global food security.

To reach the purpose of research, the following tasks were addressed:

- to improve the ontological foundations of agricultural internationalization to identify the relationship with the parameters of sustainable development, food security and clarify the terminological apparatus;
- to systematise the main theoretical models of development and internationalization of the agricultural sector in order to assess the possibilities of their adaptation to the modern realities of China;
- to theoretically substantiate the evolution of global and national strategies for the internationalization of agricultural sector to elaborate proposals for improving China's agricultural policy;
- to study the sectoral and regional structure of Chinese agriculture in order to identify centers of dynamic agricultural development, on which the strategy for the internationalization of agriculture will be based;
- to analyse the role of China in global agricultural trade to determine the commodity structure of exports and imports, main trading partners and features of trade policy, which will allow identifying directions for implementing the country's agricultural internationalization strategy;
- to assess China's participation in international capital transfers in the agricultural sector through foreign direct investment, mergers, acquisitions and partnerships in order to identify the country's influence on the formation of transnational agricultural value chains as elements of the agricultural Internationalization strategy;
- to identify global challenges that determine the current environment of China's agricultural Internationalization strategy;

- to justify the priorities for the transformation of China's agricultural sector in the context of ensuring productivity, environmental sustainability and social justice as a prerequisite for implementing the country's agricultural Internationalization strategy;
- to form a framework for the internationalization strategy of Chinese agriculture, taking into account the factors of influence, implementation mechanisms and opportunities for strengthening global food security.

The object of research is the process of internationalization in China's agricultural sector.

The subject of research is the theoretical and practical aspects of forming a strategy for the internationalization of Chinese agriculture, which determine the sustainable development of the agricultural sector and global food security..

Methods of research. In order to fulfill the specified purpose, this dissertation employs a series of research approaches. This research adopts a mixed methodology, integrating the quantitative analysis of statistical data (trade volume, foreign direct investment flows, agricultural production) with qualitative analysis of policy documents, academic literature and case studies. Particularly, the method of theoretical generalization – to provide a theoretical framework in the field of agricultural internationalization and sustainable development; the methods of analysis and synthesis – to identify the system of quantitative evaluation of agricultural internationalization; the methods of deduction and induction – to find out the development factors of researched issues and on their basis to elaborate the strategic vectors of sustainable development and food security by means of internationalization of agriculture; method of cluster analysis – to reveal the pattern of agricultural development of Chinese provinces; the tabular and graphical methods – to visualize data and key research results.

A wide range of **informational data sources** are used, including reports from the FAO, The World Bank, China's National Bureau of Statistics, China Customs, Ministry of Agriculture and Rural Affairs, Chinese Academy of Agricultural Sciences, Ministry of Commerce, China Global Investment Tracker, along with relevant academic journals and publications.

Scientific novelty of the obtained results. This study proposes an innovative framework for agricultural Internationalization and sustainable development, integrating concepts of development, Internationalization, and food security while analyzing China's transformation, sustainability evaluation methods, and the global impact.

The following most important scientific results were obtained in the research:

First obtained:

– a strategy for China's agricultural internationalization has been formed, aimed at ensuring sustainable development of agriculture and strengthening global food security through the use of tools within five strategic pillars: expanding trade to diversify imports, investing in overseas agricultural zones, promoting technology transfer and innovation, developing infrastructure and logistics, and coordinating international policy and cooperation.

Improved:

– the ontology of agricultural Internationalization as a process of integrating the national agricultural sector into global economic, trade and institutional systems in order to expand access to external markets, transfer agricultural technologies, optimize supply chains and attract investments, which, in conjunction with sustainable development strategies, contributes to strengthening global food security, ecological balance of production and socio-economic stability of rural areas;

– a system for assessing the role of international capital flows in China's agricultural sector, on the basis of which strategic initiatives of the country's government to direct flows of outward foreign direct investment to developed countries, as well as the initiation of public-private partnership projects with less developed countries, which in the complex significantly contributed to the modernization of agriculture in China and recipient countries, as well as ensuring food security and implementing sustainable practices in the world;

– the proposals on the main directions of China's agricultural transformation as a prerequisite for implementing the country's agricultural Internationalization strategy, which include: (1) developing science, technology and innovation to increase productivity through the introduction of smart farming, genetic improvement and precision farming; (2) promoting sustainable agricultural development through eco-agriculture, circular systems and low-carbon technologies; (3) strengthening financial support through the development of insurance, access to credit and the creation of sectoral funds; (4) reforming land relations and business models through legal changes, the development of family farms and cooperatives; (5) modernizing the agricultural production chain through deep processing, brand development, unification of export standards and the development of cross-border e-commerce to increase added value and competitiveness at the global level.

Further Developed:

– conceptual justification of agricultural progress and internationalization with the following key aspects highlighted: technological innovation, resource efficiency, environmental sustainability, economic optimisation and political support.

– criteria for assessing the sectoral and regional structure of the agricultural sector, in particular, a cluster analysis of Chinese provinces was conducted using hierarchical methods, which allowed us to identify clear regional differences in agricultural and economic activity, due to factors such as GDP, population distribution and agricultural specialization, which determine the limits of the implementation of the strategy of internationalization of agriculture;

– phasing the evolution of the global institutional and regulatory environment of internationalization of agriculture and identifying the impact on the national strategies of the world's leading countries, which differ in their emphasis on control over supply chains, environmental standards, export of products with high added value or integration into global trade;

– analytical approaches to identifying trends in China’s international agricultural trade, including trade cooperation with Ukraine, in particular with a focus on diversification of supply sources, structural transformation and the introduction of sustainable practices to ensure food security and promote global agricultural progress;

– determination of global challenges and imbalances in agricultural development, including population growth, resource constraints, infrastructure gaps, climate change and soil degradation to highlight their impact on food security and emphasize the need to implement sustainable practices and expand international cooperation in the agricultural sector.

The practical significance of the results obtained lies in the development of applied approaches to the formation of strategies for the internationalization of the agricultural sector, which can be used in the activities of state bodies, international organizations, investors and agricultural companies to ensure food security, sustainable development of agriculture and optimization of international cooperation. In particular, the cluster analysis of Chinese provinces allows taking into account regional features when planning agricultural policy, and the systematization of internationalization models offers effective tools for developing strategies for international partnership, diversifying supply chains and introducing innovative technologies. The recommendations formed in the work can be directly applied in the development of cooperation programs between China and Ukraine, as well as in the formation of policies aimed at adapting agricultural systems to global challenges, such as climate change, soil degradation and water scarcity.

Personal contribution of the applicant. The dissertation was completed independently by the author, incorporating all scientific findings, as well as scientific-practical recommendations and steps proposed for implementation in public policy, derived from the author's own scientific research and developments.

Approbation of the results of the dissertation. The primary outcomes of the dissertation were discussed at International Scientific and Practical Conference: "International Economy in Conditions of Climate Change: Pandemic and Post-Pandemic Period" (Ternopil, 2022); 2nd International Scientific and Practical Conference of Students and Young Scientists "International Economy in Conditions of Climate Change: Pandemic and Post-Pandemic Period" (Ternopil, 2023); International Scientific and Practical Conference "Features of the Integration of Countries into the World Economic and Political-Legal Space" (Kyiv, 2023); 3rd International Scientific and Practical Conference "International Economy in Conditions of Climate Change: Global Challenges" (Ternopil, 2024).

Publications. The main results of the dissertation research were published in 9 articles with a total volume of 4.85 p.s (of which the author personally owns 3.57 p.s.), including: 5 – publications in Journals of category “B” of the list of scientific and specialized publications of Ukraine by specialty: 051 “Economic”; 4 – publications in conference paper collections.

The structure and volume of the dissertation. The dissertation consists of an introduction, three chapters, conclusions, a list of references, and annexes. The total volume of the dissertation is 226 pages, of which 180 pages are the main text. The dissertation contains 45 tables, 33 figures and appendices on 10 pages. The list of references includes 256 sources on 23 pages.

CHAPTER 1.
THEORETICAL FOUNDATIONS OF INTERNATIONALIZATION IN THE AGRICULTURAL SECTOR

1.1. The Ontology of Global Agricultural Development and Sustainability

Agriculture is the cornerstone of human civilization, but with population growth, climate change and resource depletion, global agriculture faces unprecedented challenges. Addressing the challenge of meeting food demand while maintaining environmental sustainability and promoting social equity has become a critical focus in agricultural research. In its report titled "The State of the World's Land and Water Resources for Food and Agriculture", the FAO defined agriculture as the use of land, water, and other natural resources to produce food, fiber, and a variety of products. This goal is accomplished through a combination of crop production and animal husbandry [185].

From an ontological point of view, agriculture is not only a material production activity, but also a complex phenomenon in the socio-ecological system, which is influenced by multiple natural and social factors. Agricultural development has progressed through four phases: primitive agriculture, traditional agriculture, modern agriculture, and contemporary agriculture. From the domestication of crops and the rise of animal husbandry about 10,000 years ago, to the mechanization and application of chemical fertilizers during the Industrial Revolution, to the breakthroughs in modern biotechnology and smart agriculture, every change in agriculture has driven a leap in productivity and a transformation of human lifestyles [171].

To guarantee global food security, preserve ecological balance, and address climate change, agricultural transformation must follow the path of sustainable development. Promoting sustainable farming practices plays a crucial role in optimizing resource utilization, enhancing production efficiency, alleviating environmental stress, and fostering long-term economic and social progress. Research on sustainable agricultural development should first examine the connection between agricultural progress and human society, and investigate ways to achieve sustainable agriculture within the context of preserving ecological balance and social equity in a complex dynamic system (Table 1.1).

Table 1.1

Key elements of agricultural development

Dimensions	Key elements	Specific content	Function
Natural elements	Land resources	Soil fertility, land area, land quality, soil type, etc.	Provide a basic place for agricultural production, affecting the types and yields of crops.
	Water resources	Rivers, lakes, groundwater, precipitation, etc.	Assess irrigation conditions, which influence the temporal and spatial arrangement of agricultural production.
	Climate conditions	Temperature, precipitation, light, seasonal changes, etc.	Affect the growth cycle, planting system and occurrence of pests and diseases of crops.
	Biodiversity	Wild animals and plants, microorganisms, genetic resources, etc.	Maintain ecological balance, provide resources for biological control and genetic improvement.
Technical elements	Agricultural mechanization	Tractors, harvesters, irrigation equipment, etc.	Improve labor productivity, reduce labor costs, and expand production scale.
	Digital agricultural technology	Satellite remote sensing, Internet of Things, big data, drones, etc.	Achieve precision agriculture, optimize resource allocation, and improve production efficiency.
	Biotechnology	Genetically modified technology, biological breeding, biological fertilizers, biological control, etc.	Enhance crop resilience to pests and diseases, boost productivity, and minimize fertilizer and pesticide application.
	Precision agricultural technology	Precision fertilization, precision irrigation, precision sowing, etc.	Improve resource utilization efficiency, reduce waste, and reduce environmental impact.
	Sustainable agricultural technology	Conservation farming, ecological agriculture, organic agriculture, etc.	Protect the ecological environment and guarantee the long-term sustainable development of agriculture.
Socio-economic factors	Market mechanism	Agricultural product prices, market demand, trade policies, market access, etc.	Affect farmers' planting decisions and income levels.
	Policy support	Agricultural subsidies, tax incentives, land policies, agricultural insurance, etc.	Improve farmers' enthusiasm and promote agricultural modernization.
	Labor structure	Factors such as the size, quality, and demographic trends of the agricultural workforce, among others.	Affect the efficiency and sustainability of agricultural production.
	Rural infrastructure	Transportation, warehousing, logistics, communications, etc.	Minimize production costs while enhancing the efficiency of agricultural product distribution.
	Farmer education and training	Agricultural technology training, vocational education, agricultural innovation and promotion, etc.	Improve farmers' technical level and innovation ability and promote agricultural modernization.
	Food security and nutrition	Food production, storage, distribution, nutritional diversity.	Guarantee basic human survival needs and promote social stability.

Source: Organized by the author

Global agricultural development is influenced by many factors, and by considering agricultural development as a from an ontological perspective, the key elements of agricultural development include natural ecosystems, human production activities, technological applications, and socio-economic structures [16].

Sustainable agriculture is a deepening of agricultural development, and sustainability is not just about economic, social and environmental balance, but also a philosophical reflection on "ways of being", which FAO defines as "agricultural practices that meet current food and livelihood needs without compromising the natural resource base and the ability of future generations to meet their needs" [23].

The FAO defines sustainable agriculture as "agricultural practices that meet current food and livelihood needs without jeopardizing the natural resource base and guaranteeing the ability of future generations to meet their needs". For example, FAO data indicates that approximately one-third of the world's soil has become unproductive due to excessive tillage, and that implementing sustainable agricultural practices can significantly improve soil quality and boost productivity. Sustainable agricultural systems differ significantly from conventional agriculture in terms of philosophy, technology, goals, and practices, focusing on enhancing agricultural productivity while preserving the long-term sustainability of the agricultural ecosystem [187].

According to the comparative analysis in Table 1.2, there are significant differences between traditional and sustainable agriculture in several dimensions. Regarding input expenses, conventional systems depend on synthetic fertilizers and pesticides, potentially causing long-term soil degradation and increasing pollution control costs. In contrast, sustainable approaches minimize chemical reliance by utilizing organic fertilizers, crop rotation, and other natural inputs, thereby progressively lowering environmental remediation expenditures [190].

In terms of labor demand, traditional agriculture is in moderate demand due to the popularization of mechanization, but is vulnerable to climate fluctuations; sustainable practices require more manpower due to ecological management, but the employment structure is more stable. Regarding yield stability, traditional mono-crops and external inputs lead to fluctuating harvests, while sustainable systems enhance climate resilience through diversification and soil health maintenance [105].

Table 1.2

Comparison of traditional and sustainable agricultural systems (FAO, 2018)

Core differences	Traditional agriculture	Sustainable agriculture
1	2	3
Input cost (fertilizer, etc.)	Dependence on artificial fertilizers and chemical pesticides can readily result in soil deterioration and contamination.	Applying organic fertilizers and bio-pesticides, along with encouraging crop rotation and intercropping, helps minimize chemical input.
Stability of labor demand yielding	Medium variant (sensitive to climate shocks)	Highly stable (resistant to climatic shocks)
Water management	Crude irrigation (e.g., diffuse irrigation), which wastes a lot of water.	Drip and micro-irrigation technologies, combined with rainwater harvesting and recycling.
Energy consumption	High energy consumption (mechanical fuel, greenhouse heating, etc.).	Renewable energy (solar, biomass) and energy efficiency technologies.
Seeds and varieties	Relying on a limited number of high-yield hybrids compromises genetic diversity.	Conservation of local varieties and development of resilient non-GM crops.
Environmental impact	High (soil degradation, pollution dispersion, GHG emissions)	Low (soil retention, GHG reduction)
Market price	Dependent on commodity price volatility, margins are squeezed by middlemen.	High-value-added products (organic certification, geographical indications) boost premiums.
Employment model	Mechanization replaces labor and rural exodus.	Labor-intensive eco-agriculture (e.g., if garden management) creates local employment.
Policy and global development	High subsidies in developed countries (e.g., EU Common Agricultural Policy CAP) encourage overproduction and distort global markets.	International initiatives (e.g. UN SDG2), market mechanisms (carbon trading and ecological offsets) and technological innovations (AI monitoring, vertical farming) together promote

Source: Organized by the author

In terms of environmental impacts, traditional methods lead to soil degradation, greenhouse gas emissions and high energy consumption (reliance on oil-fired machinery); sustainable measures focus on soil carbon sequestration, application of renewable energy (solar energy, etc.) and pollution prevention and control. In terms of market prices, conventional agricultural products are squeezed by intermediaries, while sustainable products earn a higher return based on an eco-premium. In addition, whereas traditional policies often stimulate overproduction through subsidies, global trends are driving a synergy between carbon trading, technological innovation and international initiatives (e.g., SDG2) to promote sustainable agriculture [175].

Promoting sustainable agriculture is key to harmonizing food production and environmental protection, with core principles and a practical framework that includes environmental sustainability, economic viability, social equity and policy governance. Environmental sustainability emphasizes sustainable management of land, water, energy, and biodiversity, such as saving 30-50% of irrigation water through drip irrigation (World Bank data) [170]; and a 10% reduction in biodiversity in agro-ecosystems reduces crop yields by an average of 9% (Nature).

Economic viability emphasizes enhancing output per unit of resource through technological innovation, improving post-harvest storage, processing and transportation to reduce losses and waste; actively pursuing fair market access, supporting smallholder farmers to connect to markets, and promoting fair trade and value chain integration. Social equity emphasizes the protection of farmers' rights and interests, food security and nutrition, and rural development, such as Fairtrade certification, which raises farmers' incomes in developing countries by an average of 20 per cent (Fairtrade International); guaranteeing that everyone has access to sufficient, safe, and nutritious food; and directing investments toward infrastructure, education, and health services[191].

Creating an evaluation index system is essential for systematically analyzing the effectiveness of sustainable agricultural practices. Numerous experts and researchers worldwide have explored this topic extensively, resulting in the creation of diverse evaluation frameworks for sustainable agricultural development, each based on distinct viewpoints. Zhang Zhonggen and Ying Fengqi (2003), on the basis of summarizing the views of many domestic and foreign researchers in this field and consulting 25 experts in the field of sustainable agricultural development, constructed a system of evaluation indicators consisting of five subsystems and 32 indicators.

Table 1.3

Agricultural sustainable development evaluation index system

Subsystem	Indicators	Meaning of indicators
Population system	Regional population density	Reflecting rural human resource structure and population pressure
	Proportion of rural working population	
	Proportion of the Pure Agricultural Labor Force	
	The mean years of education for the rural labor force	
Economic system	Per capita agricultural GDP at the regional level	Measure agricultural production efficiency and marketization level
	Productivity of the agricultural workforce	
	Productivity of agricultural land	
	Agricultural intermediate consumption productivity	
	Proportion of rural non-agricultural industries	
	Mujun agricultural machinery total power	
	Agricultural comparative advantage coefficient	
	Commodity rate of agricultural products	
	Annual Per Capita Net Income of Rural Residents	
Social system	mean years education attained by the rural labor force.	Assess urban-rural equity and public service coverage
	Engel coefficient of rural residents	
	The count of agricultural science and technology professionals per 10,000 agricultural workers.	
	The quantity of doctors and health workers per thousand individuals in rural regions.	
	The count of telephones per 100 individuals in rural regions.	
	Regional urbanization level	
	Regional kilometer density	
Resource system	Regional per capita cultivated land area	Quantify the intensity and sustainability of natural resource utilization
	Regional water resource density	
	Land multiple cropping index	
	Flat specific gravity	
	Effective irrigation rate of cultivated land	
Environ-mental system	Regional wastewater discharge density	Assess the detrimental effects of agricultural practices on the ecosystem.
	forest coverage rate	
	Pesticide use intensity	
	Fertilizer use intensity	
	Proportion of area affected by natural disasters	
	Disaster resistance rate	
	Proportion of soil erosion area	

Source: Organized by the author

Analyzed through the Table 1.3, the agricultural sustainable development assessment indicator system is a multidimensional integrated framework. The system integrates the five dimensions of population, economy, society, resources and environment into a unified framework, breaking away from the single economy-oriented evaluation model. The indicator design aligns with the specific traits of

Chinese agriculture. Through quantitative scoring, the efficiency, equity and ecological impact of agricultural development can be systematically assessed to provide data support for the formulation of scientific policies and the optimization of agricultural practices [187].

The complexities and evolving nature of agricultural systems are receiving growing attention in the pursuit of sustainable global agricultural development. As globalization accelerates, agricultural systems are increasingly affected by cross-border factors, including market volatility, technology diffusion, climate change and geopolitics. These factors are intertwined, so that the objective of sustainable agricultural development is no longer limited to a single nation or area, but needs to be addressed jointly through international cooperation and global governance. It is against this backdrop that the strategy of internationalization of agriculture has gradually become a key path to achieving the goal of sustainable agriculture.

Philip McMichael (1994) put forward the concept of "globalization of agriculture" in Global Agro-Food System. Internationalization of agriculture refers to the flow of factors such as agricultural production, trade, investment and technology across national borders to form a global industrial chain and market network. It refers to the flow of agricultural production, trade, investment, technology and other factors across national borders, forming a global industrial chain and market network. Its core lies in optimizing the allocation of agricultural resources through transnational cooperation and resource integration, and enhancing the efficiency of the global food system, but it is also accompanied by problems such as market monopoly and ecological risks, etc. Stefano Ponte (2009) systematically analyzed the division of labor and power relations in the value chain in the internationalization of agriculture in The Globalization of Food and Agriculture, and included the flow of technology and capital in the scope of the definition. A series of research results have laid the theoretical foundation of agricultural internationalization.

Internationalization in general is a multifaceted concept and could be interpreted from different perspectives (see Fig. 1.1). In this thesis we will stick to the definition from economic perspectives.

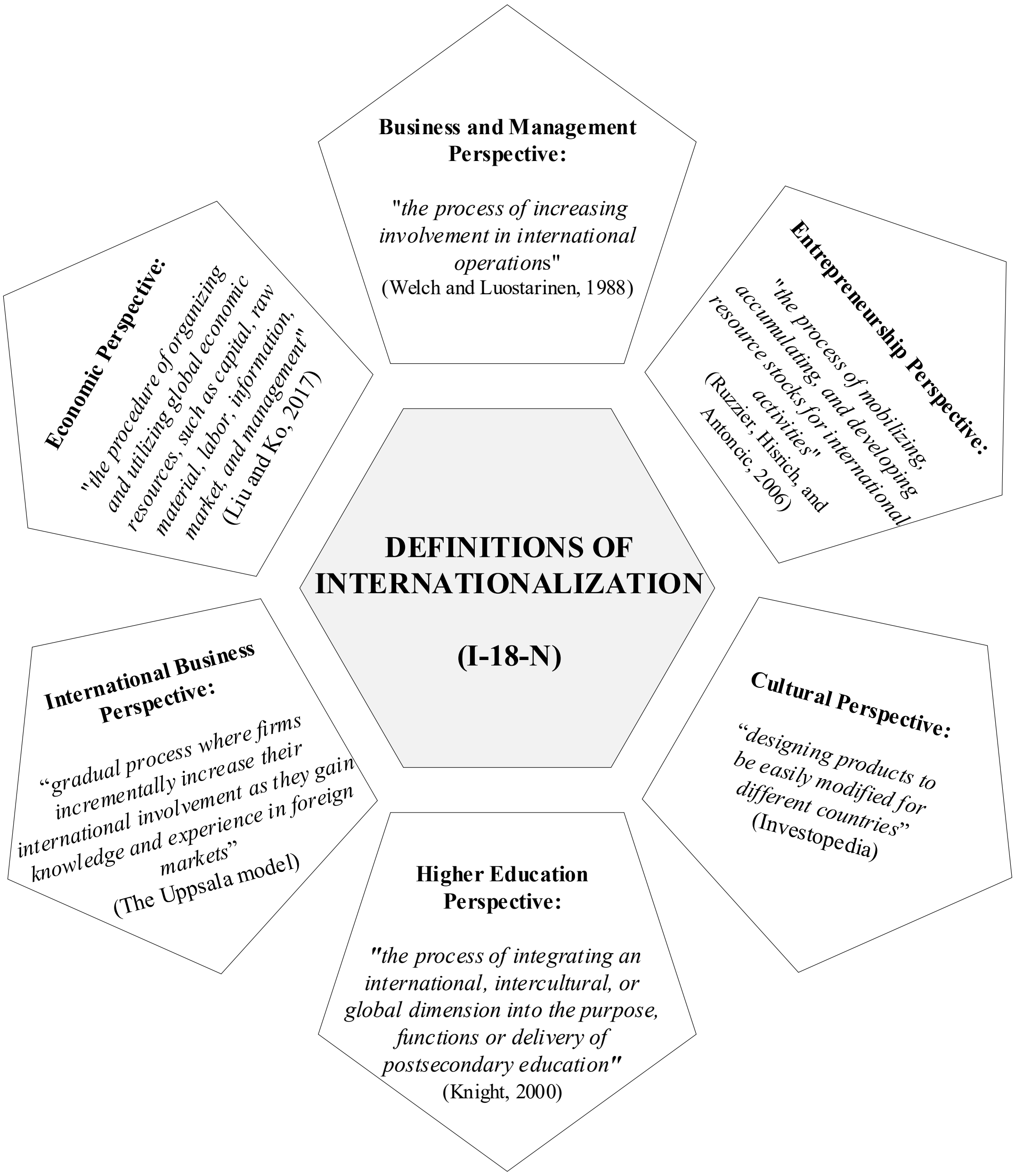


Fig. 1.1. Definitions of Internationalization

Source: Systemized by author

International trade theory is the cornerstone of the internationalization of agriculture. Classical international trade theory, with comparative advantage at its core, advocates that countries should implement labor division and trade in accordance with their resource allocations and comparative advantages to attain the most efficient global resource distribution. Building on this, the new international trade theory suggests that imperfect competition and market structure are significant factors driving international trade.

The internationalization of agriculture has flourished under this theoretical framework, and countries have realized the optimal allocation of agricultural resources and the improvement of agricultural output through agricultural trade cooperation. It is worth pointing out that traditional international trade theories focus on North-South trade, and have limited explanatory power for trade phenomena. The rise of significant intra-industry trade among developed countries has led to the emergence of factors such as imperfect competition, economies of scale, and externalities. These components offer a more detailed insight into the factors affecting international trade and the allocation of its benefits. Consequently, the new trade theory, which emphasizes scale returns and imperfect competition, provides a novel perspective and theoretical foundation for the globalization of agriculture.

International investment theory is another important theoretical basis for the internationalization of agriculture. Direct investment by TNCs is crucial to the internationalization of agriculture. According to the international investment theory, through outward direct investment, TNCs realize increase global agricultural output. In addition, international investment theory also emphasizes that TNCs' investment facilitates the spread of advanced agricultural technology and management practices, thereby promoting agricultural modernization. For example, Dutch multinational agricultural companies have played a role in increasing agricultural productivity and enhancing the quality of agricultural goods in numerous developing countries across the globe by providing technology and investing in infrastructure. Similarly, Chinese agricultural investment projects in Africa not only brought advanced irrigation technology and agricultural machinery to the region, but also helped to increase food production and the efficiency of agricultural production in Africa by imparting modern farming and management skills to African farmers through training and cooperation.

The theory of international cooperation is a strong support for the internationalization of agriculture. This theory suggests that through collaboration, nations can collectively tackle global issues such as food security and climate change. Within the agricultural sector, international cooperation enables countries to address the challenges of agricultural development together and share the benefits of this progress. The globalization of agriculture is driven by the principles of international cooperation, allowing nations to achieve sustainable agricultural growth by enhancing collaborative efforts in this field. In response to global food security and other challenges, international collaboration becomes especially crucial. By sharing knowledge, providing technical assistance, and aligning policies, countries can work together to advance agriculture and ensure the resilience and sustainability.

Internationalization of agriculture facilitates the efficient distribution of worldwide agricultural resources, boosts agricultural production, and aids in mitigating global food security concerns. Additionally, the internationalization of agriculture supports the spread of advanced agricultural technologies and management practices, enhancing technological capabilities in various countries and driving agricultural modernization. Furthermore, it encourages international collaboration in agriculture, providing substantial support for addressing global agricultural issues. Nevertheless, it also encounters challenges that could intensify inequality and dependency, particularly in developing nations. One notable aspect is trade dependency. In the last two decades, the proportion of international trade in the global economy has risen considerably, serving as a critical income source for developing countries (Table 1.4).

Nevertheless, numerous low-income countries have traditionally depended on the production and export of agricultural products. Excessive reliance on food imports renders these nations susceptible to price fluctuations and disruptions in global supply chains. For instance, the COVID-19 pandemic highlighted the fragility of the global food system, as trade restrictions and logistical challenges caused substantial delays and shortages in several countries. Countries that rely heavily on food imports face higher prices, increased pressure on household budgets, and increased food insecurity. Second, unequal access to global markets is prominent. Developing countries encounter numerous challenges in integrating into GVCs, such as insufficient infrastructure, fragile institutional systems, and restricted access to financial resources. For example, smallholder farmers in sub-Saharan Africa have difficulty competing with large agribusinesses in export markets due to limited productive capacity and difficulties in accessing modern inputs and technologies. In addition, power imbalances in trade negotiations can lead to unfavorable conditions for developing countries, limiting their ability to benefit from internationalization.

Table 1.4

Comparison of challenges and opportunities brought by internationalization to developed and developing countries

Aspect	Developed countries	Developing country
chance	Enter a larger market and export high-value crops.	Access to technology, foreign direct investment, improving food supply
challenge	Environmental problems caused by large-scale agriculture	Trade dependence and unequal market access
technological innovation	Advanced mechanization and precision agriculture	Limited access to inputs and technology.

Source: generated by the author

The Table 1.5 highlights the extent to which different regions rely on imports for food security, detailing the proportion of food imports and the main crops imported in each region. The MENA region demonstrates the highest level of dependence on food imports, as half of its food supply is sourced from international markets, and imports of basic foodstuffs such as wheat, rice and sugar, reflecting the region's limited agricultural production capacity. Sub-Saharan Africa has a food import dependence of 20 percent, importing mainly staple crops, which are particularly Significant in areas where local production is insufficient. South-East Asia has a relatively low food import dependence of 10 per cent, importing mainly commodities with limited local production, such as wheat and dairy products, but the region as a whole has a strong agricultural production capacity. Latin America has the lowest food import dependence at 5 percent, importing mainly dairy products and cereals, although many countries in the region are net food exporters but still need to import some commodities. The data in the table reveal differences in the level of dependence on global food trade by region, with some regions being more vulnerable to supply chain disruptions due to their dependence on imports of basic foodstuffs.

Table 1.5

Food import dependency by region

Region	Food Import Dependency (%) $IDI = \frac{Imports}{Production+Imports-Exports} \times 100\%$	Key Imported Crops
Middle East &North Africa	50%	Wheat, rice, sugar
Sub-Saharan Africa	20%	Wheat, maize, rice
Southeast Asia	10%	Wheat, dairy products
Latin America	5%	Dairy products, grains

Source: World Bank Global Food Security Database

The export-oriented agricultural production model tends to promote the expansion of monocropping and intensive farming, which in turn leads to problems. In Brazil, for example, deforestation in the Amazon region is a growing problem to satisfy the demand for soybeans in the international market. Address this challenge, countries are gradually implementing sustainable trade policies that promote environmentally friendly production, such as the promotion of certification systems such as Fairtrade and the Rainforest Alliance, which not only encourage sustainable production methods, but also safeguard the legitimate rights and interests of laborers. Meanwhile, climate-smart agriculture (CSA) approaches are being incorporated into international trade frameworks to improve the resilience of agricultural systems to climate change [51].

Sustainable agriculture and food security are fundamentally interconnected. Food security is a key pillar for ensuring social stability, supporting the continuous and healthy progress of the national economy, and achieving long-term national peace and stability. The United Nations launched the 2030 Agenda for Sustainable Development in 2015, which highlighted food security as a key global development priority. This agenda built upon and expanded the earlier Millennium Development Goal (MDG), which aimed to "eliminate extreme poverty and hunger and reduce by half the number of people suffering from hunger between 1990 and 2015". The 2030 Agenda underscores the critical importance of food security in shaping global development. This marks a shift from the previous Millennium Development Goal, which aimed to "eradicate extreme poverty and hunger and halve the proportion of people suffering from hunger between 1990 and 2015". The new SDGs not only lay emphasis on eliminating hunger, but also further stress the significance of sustainability and nutrition. Specifically, the aim is to reach "zero hunger" by 2030, guarantee food security, enhance nutritional levels, and promote sustainable agricultural development, and specific targets have been set. These include completely eradicating all forms of hunger by 2030; significantly improving the efficiency of agricultural production; building a sustainable agricultural production system, and promoting advanced agricultural technologies to enhance the productive capacity of agriculture in less-developed regions. At the global level, sustainable agriculture cannot be realized without an effective global governance mechanism. The international community needs to jointly address the challenges of food security and sustainable agricultural development through multilateral cooperation, policy coordination and technology sharing. World organizations encouraging collaboration among nations in sustainable agriculture by establishing global standards, offering technical support, and fostering policy discussions. In addition, transnational agricultural investment, technology transfer and the improvement of market mechanisms are also important ways to realize global food security and sustainable agricultural development. In the future, global governance should pay more attention to fairness and inclusiveness and ensure that developing countries can fully participate in and benefit from the global practice of sustainable agriculture.

1.2. Theoretical Models of Agricultural Progress and Internationalization

Agricultural progress plays an irreplaceable and important role in ensuring global food security. In the 2009 World Summit on Food Security Declaration, the Food and Agriculture Organization (FAO) described agricultural progress as "achieving a balance between boosting productivity and safeguarding ecosystems through sustainable intensification". Thomas Malthus (1798) proposed in "On Population" that agricultural productivity improvement is the key to break through the "population trap".

Theodore Schultz (Theodore Schultz, 1964) in "Transforming Traditional Agriculture" systematically argued that technological progress and investment in human capital promote agricultural modernization, laying the theoretical foundation of agricultural progress. To investigate the intricate dynamic mechanisms within the agricultural system, scholars have actively constructed theoretical models through the analysis of key dimensions of agricultural progress, and analyzed the driving factors of agricultural growth in a systematic way.

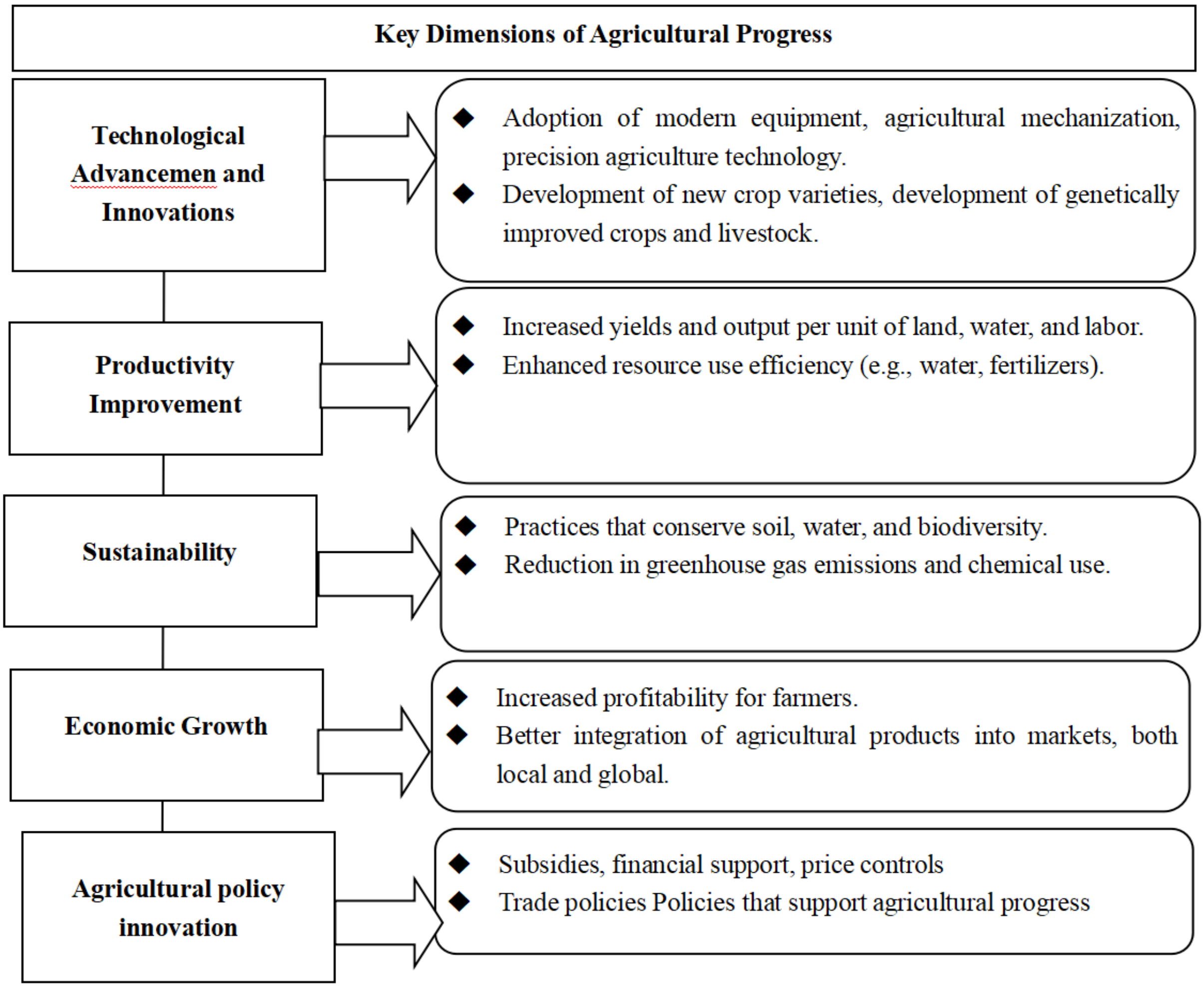
Through examining the table, it is evident that the key dimensions of agricultural advancement encompass five primary areas: technological innovation, productivity improvement, ecological protection, economic optimization and policy support. Technological innovation includes the application of mechanized equipment and crop genetic improvement; productivity improvement focuses on the efficient use of land, water and labor per unit; sustainability emphasizes soil protection, emission reduction and pollution control, and biodiversity preservation; economic growth is achieved through the enhancement of farmers' profitability and the expansion of markets (both locally and globally); and policy innovation promotes systemic change through subsidy mechanisms, optimization of trade rules, and financial support (Fig. 1.2).

During the process of globalization, agricultural advancement is achieved through technological innovation, driven population pressure is a central driver in the study of agricultural progress and technological innovation.

Table 1.6 compares Boserup's model of agricultural intensification (1965) with Malthus's theory of population-food balance (1798), which differentiates population growth and agricultural development. Boserup's theory highlights that population growth drives improvements in land productivity by necessitating technological advancements. Notable examples of this include the introduction of high-yielding varieties in Asia and Africa, as well as the intensification of farming through their adoption [26].

Typical cases include Asia and Africa through the promotion of high-yielding varieties to achieve intensification of farming. In contrast, the Malthusian model points out that exponential population growth inevitably exceeds the linear supply of food, which ultimately leads to resource depletion and social crises, as evidenced by the famines in pre-industrial Europe due to the lagging of food production capacity behind population expansion. The essence of the conflict between the two theories lies in the difference in the perception of technological potential: Boserup argues that innovation can break through resource constraints, while Malthus presupposes the finiteness of technological progress.

Fig. 1.2. Key dimensions of agricultural progress



Source: Organized by the author

Historical practice provides empirical evidence to reconcile the two - The Green Revolution in the 20th century brought about a significant rise in food production in Asia and Latin America by introducing high-yield crop varieties and fertilizers and irrigation techniques, validating Boserup's technology-driven pathway and highlighting both the ecological costs of the Malthusian warning. This indicates that agricultural advancement must strive to achieve a dynamic equilibrium between technological innovation and sustainable resource management.

Table 1.6

Comparison of agricultural theories

Model	Core Idea	Example
Boserups Theory of Agricultural Intensification (1965)	Population growth drives agricultural innovation	The shift to intensive Farming in Asia and Africa
Malthusian Theory of Population and Food Supply (1798)	Population growth leads to food scarcity unless controlled	Food shortages in pre-industrial Europe

Source: completed by the author

Internationalized agricultural flows are another driver of agricultural internationalization. The system of agricultural progress has been reconfigured through multidimensional factor flows, enabling countries to cooperate, trade and exchange technology, share resources and development opportunities, and ultimately improve the efficiency and comprehensive level of global agricultural output (Fig. 1.3).

Global agricultural flows and forms of development demonstrate the multifaceted character of the internationalization of agriculture. Global trade in agricultural goods has led to a broader range of food sources and a more efficient agricultural production structure. The spread of agricultural technologies and knowledge, particularly to developing nations, along with transnational investments in agriculture, has enhanced infrastructure and boosted production capacities. Additionally, international collaboration on food security and climate change has been enhanced through the coordination of global agricultural policies. The establishment of global agricultural supply chains has enhanced the efficiency of resource allocation and contributed to the specialization of agricultural production.

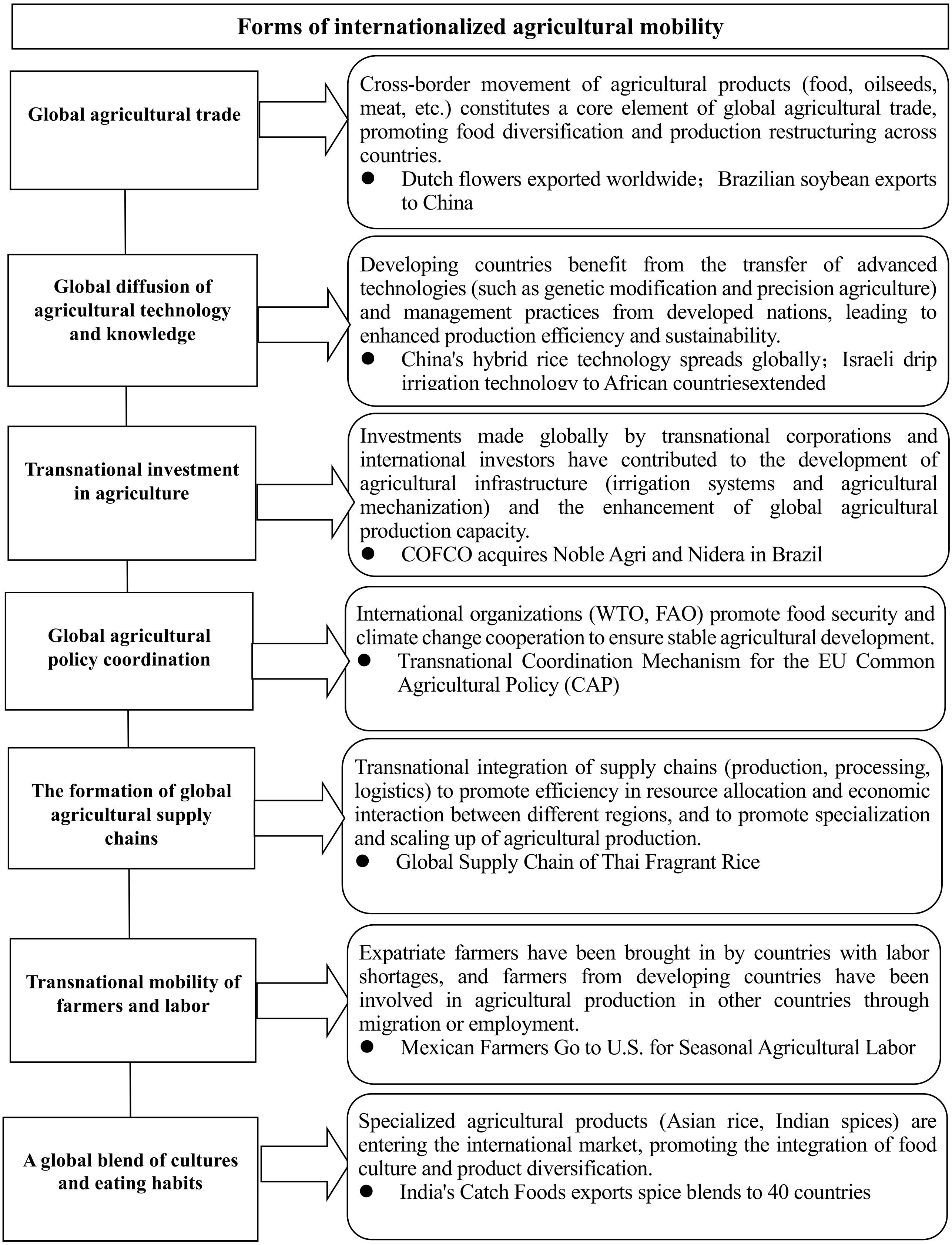


Fig. 1.3. Forms of internationalized agricultural mobility

Source: Organized by the author

In addition, the transnational migration of farmers and transnationals, as well as the global convergence of cultures and cuisines, have further expanded the impact of the internationalization of agriculture. Together, these factors have created a complex network of global agricultural flows and development, which has not only reshaped global agricultural production and trade patterns, but also triggered an in-depth exploration of theories of agricultural development.

The internationalization of agricultural trade could be explained by a number of theoretical models:

1. The principle of comparative advantage was introduced by British economist David Ricardo. The theory holds that countries should concentrate on producing those commodities that exchange them for other commodities through international trade in order to maximize resources Ricardo's theory of comparative advantage has profoundly influenced the development of economics and provided the theoretical basis for the theoretical model of agricultural progress and internationalization. With agricultural technology continues to advance, nations are capable of producing a greater quantity of agricultural products, and the international trade of these products not only promotes the global circulation of agricultural products, but also accelerates the process of economic integration between places. Especially for those countries with rich agricultural resources, they are able to rely on their comparative advantages in agricultural production to carry out efficient trade exchanges compared with other countries, which promotes the optimal allocation of global agricultural products and the efficient use of resources. Agricultural production and trade in the process of internationalization serve as a key application of the theory of comparative advantage and a foundational element for the expansion and advancement of the global economy. [95].

2. The Global Value Chain (GVC) theory focuses on the integration of all stages, from sourcing raw materials to efficient final consumption, with the goal of enhancing the added value and market competitiveness of agricultural products (Gereffi, 2005) [87]. The GVC model focuses on the leading firms and their relationships with multinational suppliers, distributors, and retailers, and explains how to add value at

every stage of production to add value to improve supply chain efficiency. In agriculture, lead firms usually dominate production conditions, quality and delivery times. For example, a smallholder farmer or supplier may be integrated into a global supply chain for, say, coffee or cocoa, in which international buyers set stringent quality standards.GVC theory emphasizes upgrading opportunities-local suppliers or producers can move to higher-value-added segments of the value chain by upgrading their capabilities. For example, a country dominated by primary agricultural products could move towards processing and branding to capture more value.

3. The Food Sovereignty Model offers an alternative development path for global agricultural systems by emphasizing the integration of localized production, smallholder protection, ecologically sustainable agriculture, policy autonomy and cultural values. The model advocates reducing dependence on external markets and increasing the food self-sufficiency of communities, while ensuring that smallholder farmers are able to compete fairly in the marketplace and maintain their productive autonomy through land reform, cooperatives, and participatory policy development [230]. In addition, the food sovereignty model promotes the implementation of environmentally sustainable agricultural practices that mitigate adverse environmental effects. Furthermore, it seeks to strengthen cultural identity and social cohesion within communities by safeguarding traditional agricultural knowledge and preserving food culture. [193]. This model not only aims to achieve food security, but also pursues the multiple goals of social equity and ecological sustainability, providing an important theoretical basis and practical guidance for the transformation of global agriculture [180].

Table 1.7

Differences between the global value chain theory and the food sovereignty model

Aspect	Global Value Chain (GVC)	Food Sovereignty
Decision-Making	Driven by multinational corporations	Controlled by local farmers and communities
Focus	Maximizing global efficiency and profits	Prioritizing local food security and sustainability
Market Power	Lead firms dominate	Farmers empowered through cooperatives
Environmental Impact	Large-scale, industrial farming	Sustainable, small-scale farming

Source: Organized by the author

The comparison between the global value chain theory and the food sovereignty model aims to reveal the two different development paths of the global agricultural system and their impacts on food security, social equity and ecological sustainability. The GVC theory emphasizes the integration and efficiency of global production networks and focuses on transnational collaboration and distribution of benefits, while the food sovereignty model focuses on localized production, protection of the rights and interests of smallholder farmers and ecological sustainability, and advocates for reduced dependence on external markets [159]. In terms of environmental impacts, the GVC model often results in resource depletion, deforestation, and biodiversity loss due to large-scale industrial agriculture, while the food sovereignty model advocates sustainable small-scale agriculture and emphasizes eco-friendly practices such as agroecology and crop diversification. Overall, the table contrasts the globalization and profit orientation of the GVC model with the local control, sustainability and farmer empowerment of the food sovereignty model, demonstrating different paths to agricultural development and market integration.

4. The Factor Endowment Theory, developed by Svedberg and Bertil Ohlin in the 20th century, suggests that international trade patterns are influenced by the distribution of factors of production across countries, such as land, labor, and capital [134]. Countries rich in resources tend to export land-intensive products, while those abundant in labor focus on exporting labor-intensive goods. The theory not only elucidates the structure of division of labor in global agricultural trade but also offers a theoretical foundation for nations to develop agricultural policies. It assists countries in fully utilizing their resource endowment advantages and strengthening their international competitiveness [104]. Simultaneously, the factor endowment theory offers a crucial viewpoint for analyzing resource flows and benefit distribution within the global agricultural value chain. It highlights the profound influence of international trade on resource allocation efficiency and the refinement of production structures. In agriculture, countries with abundant resources export land-intensive products, while those with a surplus of labor focus on exporting labor-intensive goods. The theory

explains patterns of resource allocation and specialization in global agricultural trade [78].

5. The theory of agricultural globalization explores how globalization has expanded the agricultural industry through trade, technology sharing and foreign investment. It identifies the advantages of greater market access, higher productivity and increased investment, while recognizing the challenges presented by the global agricultural market, including trade dependence, environmental damage and the widening gap between large agribusinesses and small farmers [214]. The theory also highlights the impact of the globalization process on agricultural policies, especially in the context of tariffs and trade agreements, policy coordination between countries has become increasingly important [82].

Table 1.8 reveals the double-edged effects of globalization in agriculture: while unleashing growth potential, structural risk challenges need to be addressed systematically. On the trade side, globalization allows countries to access wider markets and foreign exchange, but overdependence on export markets can lead to price volatility and economic instability.

Table 1.8

Benefits and challenges of globalization in agriculture

Aspect	Benefit	Challenge
Trade	Access to international markets and currency exchange.	Reliance on foreign markets and fluctuations in prices
Technology	Embracing modern farming techniques	Disparities in access, environmental
Transfer	technologies	Degradation
Investment	FDI supports infrastructure development and productivity	Dangers of reliance on foreign investment and potential capital exit

Source: Organized by the author

With regard to technology transfer, the introduction of advanced agricultural technologies had increased productivity, but technological inequalities could exacerbate the problem of environmental degradation. Foreign direct investment (FDI) has been crucial in driving infrastructure development and improving productivity.

However, over-reliance on foreign investment may lead to dependence on external finance, and withdrawal of foreign capital may undermine local agricultural progress [181]. Overall, the table summarizes the improved market access, technological advances and investment opportunities brought about by the globalization of agriculture, while also pointing out the risks of market dependence, unequal access to technology and reliance on foreign capital.

Among the theories of agricultural globalization, the Environmental Kuznets Curve (EKC), which measure trends in the agricultural development process (Fig. 1.4), provides insights into how agricultural practices can respond to the challenges of internationalization and sustainability, and shows that environmental degradation tends to increase in line with economic growth but begins to slow down when per capita incomes exceed a specific threshold [218].

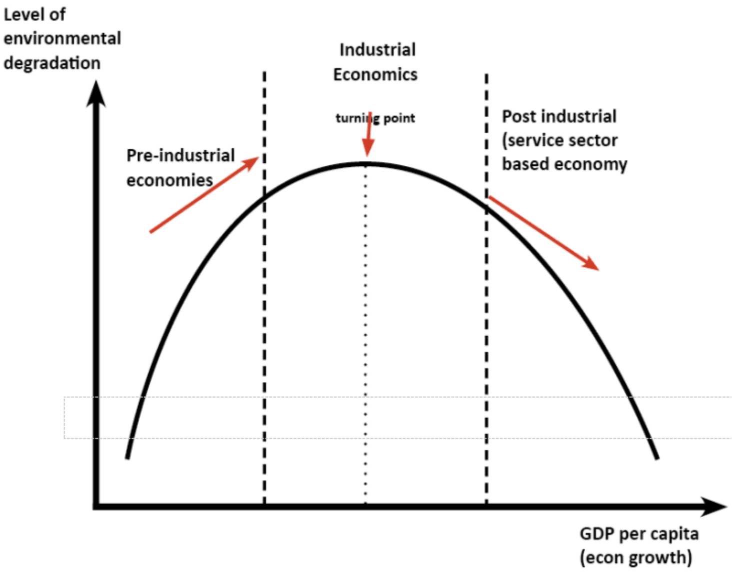


Fig. 1.4. Environmental Kuznets curve

Source: [218]

At this point, countries typically invest resources in developing cleaner technologies and implementing stricter environmental policies. This theory suggests that the initial stages of agricultural intensification may lead to greater environmental damage. However, as the agricultural sector grows and modernizes, it has the ability to adopt more sustainable practices and mitigate environmental impacts [28]. In many developing countries, agricultural expansion to meet food demand has led to deforestation, soil degradation and water depletion. As these countries progress and globalize, they gain access to advanced technologies like precision agriculture and drip irrigation, which help boost productivity while minimizing environmental harm [58].

In the axes of this graph, the x-axis represents GDP per capita, reflecting the level of economic growth, and the y-axis represents the degree of environmental degradation, which measures environmental damage at different stages of economic development. The curve has an inverted U-shape, indicating the trend of environmental degradation with economic growth [96]. The application of the Environmental Kuznets Curve (EKC) in agriculture reveals the dynamic correlation: in the low per capita GDP stage, the crude production relying on resource plundering eads to soil degradation and loss of biodiversity, which corresponds to the period of EKC rise [27]; with the transition to agricultural intensification (middle-income stage), mechanization and monoculture As agriculture intensifies (middle-income stage), mechanization and monoculture intensify carbon emissions and pollution, and environmental pressure reaches its peak [47]; when it enters the high-income stage, technological innovation, policy regulation (carbon tax, eco-subsidies), and transformation of market demand (carbon-neutral agricultural products) drive agriculture to move towards a sustainable model and achieve synergy between productivity and ecological restoration, which corresponds to the period of declining EKC. However, path dependence (technology lock-in), global value chain squeeze and climate shocks may delay the inflection point, and we need to avoid the trap of "polluting first and then treating later" through stepped technology adaptation, North-South cooperation and compensation, and localized policy design, so as to directly embed the green agriculture paradigm and harmonize the objectives of food security and ecological safety [219]. The environmental Kuznets curve shows that the trend of ecological degradation in the process of internationalization of agriculture is not inevitable, but depends on the synergy of technological innovation, policy intervention and market mechanism. Developing countries need to avoid the trap of "pollute first, treat later" and directly embed the sustainable agriculture paradigm through cross-stage technological leapfrogging and institutional innovation to realize the dual goals of food security and ecological safety [174].

6. Sustainable development model. The theoretical framework of sustainable agricultural development, as a practical paradigm of multidisciplinary cross-fertilization, realizes the optimal allocation and dynamic balance of agricultural production activities through the construction of a three-dimensional synergistic mechanism of economic systems, social systems and ecosystems [199]. In the context of globalization, the theoretical model is committed to coordinating the dialectical relationship between food security and ecological carrying capacity thresholds, while paying attention to the optimization and adjustment of rural social structure [184]. The development goals of item 2 (eradication of hunger) and item 12 (sustainable production and consumption) proposed by the United Nations' 2030 Agenda for Sustainable Development provide a systematic guiding program for the transformation of global agriculture (United Nations, 2015) [95].

This transformation process requires the establishment of economically resilient agricultural production systems that guarantee the capacity to fulfill the food requirements of the globe's 9 billion individuals while maintaining industry sustainability. Analyzing the economic dimension, the profitability of agricultural operators constitutes a core element of system sustainability [13]. According to an empirical study by the International Food and Agriculture Organization (IFAO), about 70% of food production in developing countries originates from small-scale producers, but such groups generally face multiple constraints such as limited access to capital, insufficient technological suitability, and market access barriers (Food and Agriculture Organization, 2018) [34]. This requires that policy design needs to focus on building an inclusive support system to enhance the vitality of the agricultural economy through innovative financial instruments, improving infrastructure and optimizing supply chain management. In terms of ecosystem maintenance, modern agricultural production urgently needs to establish an environmental costing mechanism [42].

Specific implementation paths include: promoting farming system innovation based on ecological carrying capacity, developing biodiversity-friendly farming models, and building a technology system for fertilizer and pesticide reduction. For example, the promotion of precision fertilizer application technology can increase the utilization rate of nitrogen fertilizer to more than 60%, while reducing greenhouse gas emissions by 30%. The social equity dimension emphasizes inclusive development through institutional innovation [10]. The focus areas cover the restructuring of the rural poverty governance mechanism, the optimization of the food distribution system, and the improvement of the producers' rights and interest's protection system. Empirical studies have shown that when the market participation of smallholder producers increases by 10%, their household income can grow by 15-20% and significantly improve regional food security [231].

Therefore, the establishment of a farmer-centered participatory development model has become a crucial component of the theoretical framework. The effectiveness of the theoretical model in practice depends on the degree of synergy among the three subsystems: the economic dimension needs to ensure that the rate of return on agricultural capital is higher than the average profitability of the society; the ecological dimension requires the internalization of environmental externalities into production costs; and the social dimension requires the establishment of a fair benefit distribution mechanism [48]. By creating a multilevel indicator system, the sustainability of the agricultural system can be accurately evaluated.

1.3. Evolution of Global and National Strategies of Agricultural Development and Food Security

Agricultural progress has consistently been vital for safeguarding food security, especially in the context of continued global population and agricultural growth and climate change that threatens agricultural productivity. This requires the implementation of proactive and comprehensive agricultural development strategies that focus on sustainable practices, technological innovation and democratization policies. Throughout its history, global agricultural development has been a complex process from reactive responses to existential crises to proactive construction of sustainable systems.

The analysis of the following five stages reveals the intertwined technological, political, ecological and social evolution:

1. Pre-industrialization period (before the 18th century). During this period, global and national agricultural systems were organized primarily around subsistence agriculture, with little emphasis on commercial agriculture, technological advances or large-scale trade networks. This phase reflects the earliest agricultural practices, driven by the needs of local communities to ensure food security and livelihoods (Table 1.9).

In short, agricultural development during this period was largely subsistence, food production was largely localized and trade was based on a barter system. Technological advances were limited, yields were low, humans were defenseless against pests, diseases and extreme weather, and food security was entirely subject to ecological contingencies [162]. Agricultural practices are community-based and there is little government or institutional involvement in food security. Food security at this stage is equated with "avoiding famine", with technological stagnation and closed systems constituting the upper limit of survival.

2. Industrial revolution and colonial agriculture (18th-19th centuries). During this period, the world's agricultural development was driven by both technological innovation and colonial policies, which reconfigured the global agricultural production system (Table 1.10). The application of steam power gave rise to equipment such as threshing machines and other devices that significantly improved the efficiency of farming, but the technological dividend was concentrated in the colonial sovereigns. The colonial authorities integrated the colonies into the global supply chain of raw materials by enforcing a monocropping system. For example, in India, under the British East India Company, cotton cultivation expanded to three times the size of food crops (1800-1850), leading directly to periodic famines in Bengal; and in Latin America, Brazil was reduced to a coffee plantation economy, with 60 percent of the world's coffee exports in 1860, at the expense of its indigenous food self-sufficiency [45].

Table 1.9

Global characteristics of pre-industrial agriculture

Perspective	Global characteristics	National characteristics
farming system	Subsistence agriculture is dominant, with production objectives centered on meeting the basic food needs of the household or community	Self-sufficiency model predominates, with high localization of food production and consumption, and very little surplus reaching markets
food distribution	Highly localized food systems that rely on intraregional circulation and lack mechanisms for large-scale circulation across regions	Significantly affected by seasonal cycles and lack of long-term storage technologies (e.g., drying, inadequate cellar facilities)
trade pattern	International trade was minimal, involving only a few exchanges of luxury goods such as spices and silks	Commodity flows are limited to local markets, with no national or cross-regional supply chain network in place
food security	Significantly constrained by natural conditions (climate, seasons) and limited capacity for food reserves at the household and community levels	The Government's role in planning and regulating agricultural production and food distribution is weak and dominated by local traditional management
technical application	Simple means of production (e.g., wooden plows, human farming), slow technological innovation, reliance on traditional experience and manual labor	Relying mainly on human and animal power, with handmade agricultural tools (such as sickles and stone mills), the degree of mechanization is close to zero.

Source: systematized by the author

The ecological costs were then realized, with Caribbean sugar cane plantations experiencing a 40% decline in production by the end of the 19th century due to soil fertility depletion triggered by continued monoculture. The ambivalence of this period was revealed in the Irish Potato Famine (1845-1852), when Britain forced Ireland to export wheat through the Grain Act, despite the fact that the crop had been wiped out by late blight, leading to the deaths of millions from starvation and highlighting the exploitative character of agricultural production within the colonial system. The initial formation of a global food trade network did not alleviate inequality, but rather exacerbated the economic divide between the core and the periphery through the price scissors.

3. Green Revolution (1940s-1970s). The Green Revolution was the most important global agricultural strategy of the twentieth century. It aimed to address widespread hunger and food shortages, especially in developing countries, through the adoption of agricultural technologies.

Table 1.10

Core elements of the industrial revolution and colonial agricultural development

Level	Core elements	Mechanism of action	Typical case
technological innovation	Steam-powered machinery, e.g., threshing machines (1784), steel plows (1837)	Improved farming efficiency and reduced labor requirements, but dependent on coal energy and industrialized production systems.	UK (textile machinery patents), France (colonial management techniques)
	Early fertilizers (Chilean saltpeter, guano)	Short-term enhancement of land yields and accelerated soil nutrient overdraft.	
colonial policy	Monoculture	Colonial powers forced colonies to concentrate on cultivating cash crops like cotton, sugar cane, and coffee, which weakened the local food self-sufficiency systems.	India (60% of cotton cultivation, 1850), Brazil (70% of coffee exports, 1880), Caribbean (sugar cane plantations)
	Land privatization and labor control (slavery, indentured labor)	Stripping aboriginal land ownership and creating a dependent labor system to guarantee a stable supply of raw materials.	

Source: Organized by the author

The Green Revolution focused on the utilization of high-yielding varieties of crucial crops, such as wheat, contemporary rice, and maize, resulting in a considerable rise in crop output. By the 1980s, wheat production in India had more than tripled from 12 million tons in 1965 to over 72 million tons [182]. The increased use of synthetic fertilizers and pesticides helped to improve soil fertility, and the expansion of irrigation networks allowed farmers to cultivate more land, reducing food production in countries such as India, Mexico and the United States, where hunger had become a major problem. It is estimated that the Green Revolution averted widespread famine, saved millions of lives, and helped reduce global poverty rates [101].

Table 1.11 lists the four basic pillars of the Green Revolution, with high-yielding varieties in particular. These hybrids, including genetically enhanced varieties of major crops like wheat and rice, are developed to boost yields. Their deployment has had far-reaching impacts, manifested in dramatic increases in agricultural productivity. This breakthrough has revolutionized the dynamics of food production, enabling growers to get more from the same amount of arable land and contributing significantly to advances in global food security.

Table 1.11

Components of the green revolution and their impacts

Component	Impact
High-Yielding Varieties (HYVs)	Increased crop productivity (e.g., wheat and rice)
Chemical Fertilizers	Improved soil fertility and boosted plant growth
Irrigation Technologies	Allowed more efficient water use, expanding cultivation in arid areas
Pesticides	Reduced losses from pests and diseases, improving crop yields

Source: Organized by the author

Chemical fertilizers are enriched with nutrients such as nitrogen, phosphorus and potassium and are used to improve soil fertility. Their use helps plants grow more robustly and increases the total crop yield. Advanced irrigation systems, including the use of canals, wells and sprinklers, have made the use of water for agriculture more efficient. This has made it possible to farm areas that were previously dry and water-stressed, increasing the amount of cultivated land. Pesticides are used to control pests and diseases that can damage crops. Their impact has been to reduce crop losses due to pests, thereby increasing yields and improving food security (Table 1.12).

Table 1.12

National and Global Agricultural Strategies for the Green Revolution Era

Strate–gies	Perspec–tive	Specific strategies and typical cases
Global collabo-ration	Internatio-nal studies	Organizations like the International Rice Research Institute (IRRI) and CIMMYT develop and promote high-yielding crop varieties (e.g., dwarf wheat, IR8 rice), while the World Bank supports technological advancements by funding irrigation projects, such as the Thar Desert Tubewell Project in India.
	Food aid and trade	Distribution of surplus food from developed countries to developing countries (e.g., the U.S. PL 480 program to provide 34 million tons of wheat to India and Pakistan), bundled with technology exports to curb communist expansion.
	Infrastruc-ture develop-ment	Establishment of high-potential farming areas and investments in roads, storage and irrigation facilities help connect rural areas to markets and reduce post-harvest losses. Punjab, India (60% of national wheat production, 1975), Luzon, Philippines (90% rice coverage in IR8, 1970), expansion of the Sonora Canal System in Mexico (1950-1970), quadrupling of irrigated area
Count-ry-level strate-gies	Policy support	Government subsidies for fertilizers, seeds and machinery made Green Revolution technologies more accessible. "nationalization of banks" in India (1969), with mandatory credit tilted in favor of large-scale farmers, and 70 per cent of farm loans for large farmers in Punjab (1975).
	Land reform	Land redistribution aims to empower small-scale farmers and reduce inequality. (For example, the Agrarian Land Reform Code of the Philippines was enacted in 1963, and the Ejido system in Mexico prohibits the sale of land.)
	Education and training	Agricultural extension programs teach farmers sustainable practices and effective use of new technologies. (For example, the "Masagana 99" program in the Philippines trained farmers to use IR8 rice and fertilizers).

Table 1.13

Impact of the green revolution on agricultural production and the environmental conditions

Perspective	Positive influence	Negative impact
Crop yield	Enhanced food production and self-sufficiency. Global cereal output grew at an average annual rate of 3% (1950-1970) and Asia's food self-sufficiency rate rose from 82% (1961) to 97% (1985). IR8 rice yields in the Philippines increased from 1.9 tons/ha to 4.7 tons/ha (1966-1975).	Soil degradation and decline in biodiversity. In the Indian state of Punjab, the extent of salinized soil increased from 3 percent in 1966 to 42 percent in 1991, and the productivity of arable land declined by 30 per cent. In Sonora, Mexico, monoculture of wheat led to the disappearance of 70% of native maize varieties (1980).
Poverty reduction	Reducing hunger and improving livelihoods. Rice exports from the Philippines increased from 0 tons in 1965 to 500,000 tons in 1975, alleviating rural poverty in the short term. Farmers' incomes in Punjab, India, increased by an average of 8 percent annually (1965-1975).	Widening inequality between large and small farmers. The rate of suicide among small farmers in India rose to 25.8 per 100,000 (1995-2005) due to debt stress. The rate of abandonment of peasant land in Mexico reached 15 percent (1980) due to technological thresholds, exacerbating the expansion of urban slums.
Water resources	Expansion of irrigation increased arable land. Expansion of irrigation increased the area under rice cultivation by 400% in Punjab, India (1960-1990). Irrigation Efficiency Improvement and Doubling of Agricultural Output in the Sonora Canal System, Mexico (1950-1970)	Over-abstraction and aquifer depletion. In the Indian state of Punjab, groundwater over-abstraction is 160%, with an average annual decline in groundwater levels of 0.4 meters (1970-1990).
Chemical input	The use of fertilizers greatly enhanced productivity, global fertilizer application continues to grow, increasing yields by 200-300 per cent between 2000 to 1950. In India, the use of pesticides reduced wheat pest damage from 20% to 5% by 1970.	Water pollution and soil nutrient depletion. In the Gulf of Mexico, 20,000 km2 of "dead zones" (2000) were created by fertilizer run-off, with fisheries losses averaging $1.2 billion per year.

Sources: Hazel, 2009; Pingali, 2012

4. Emergence of sustainable intensification (1980-2015). As the environmental drawbacks of the Green Revolution became increasingly apparent, the concept of sustainable intensification (SI) emerged as a modern approach to agricultural development. Sustainable intensification aims to enhance agricultural productivity while avoiding further environmental deterioration, thereby balancing economic and ecological objectives. This model is especially crucial within the framework of climate change, as it aims to sustain high productivity levels while minimizing greenhouse gas (GHG) emissions and preserving natural resources.

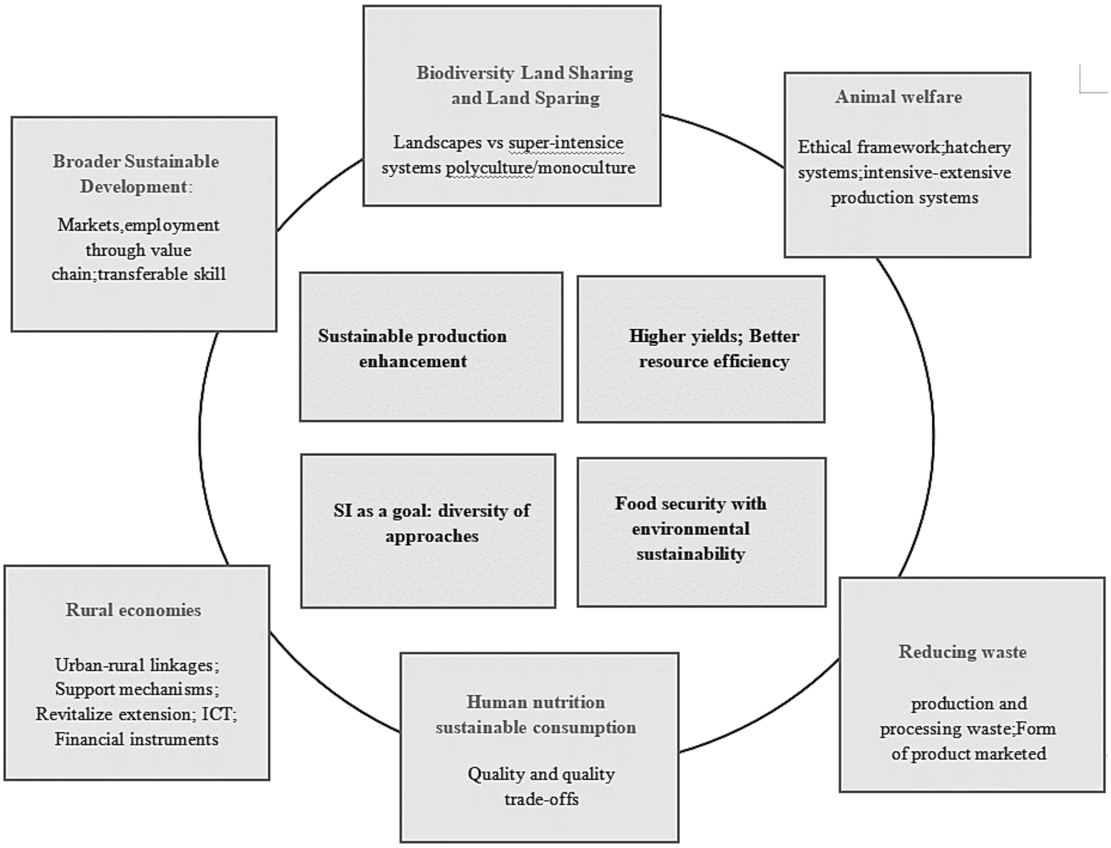


Fig. 1.5. Sustainable intensification frameworks

Source: [85]

Sustainable intensification intends to enhance the output efficiency per unit area by means of scientific and technological innovation, management optimization and policy support, without extending the area of arable land, so as to meet the current food demand and ensure the long-term sustainable utilization of resources. The core of this lies in the efficient use of resources, such as the optimization of water and fertilizer management through precision agriculture technology to reduce resource wastage; Simultaneously, technological innovations, such as biotechnology and the application of information technology, can improve crop yields and resilience to meet the challenges of climate change [85]. In addition, maintaining ecological balance is crucial, and biodiversity and soil health must be preserved while increasing yields in order to achieve long-term ecological sustainability. Policy and governance are crucial in this process, as they involve developing effective agricultural policies, providing financial support and technical training, and promoting the adoption of sustainable production practices by farmers. Social equity is also an important factor that cannot be ignored. Ensuring equal access to resources and market opportunities for smallholder farmers and large-scale agribusinesses contributes to higher levels of food security for society as a whole. The framework system integrated the multiple elements of sustainable agriculture and aimed to attain a equilibrium between farm output and environmental conservation, providing a scientific path to food security and sustainable development (Table 1.14).

Table 1.14

Green revolution vs. sustainable intensification

Aspect	Green Revolution	Sustainable Intensification
Development background	In the mid-20th century, agricultural productivity improvements were mainly concentrated in developing countries	To address environmental, social, and economic sustainability challenges while enhancing agricultural productivity
Core objectives	Increased agricultural production and solved food shortages	Enhance agricultural productivity without harming the environment, secure food availability, and promote the sustainable utilization of resources.
Technology dependence	The widespread use of fertilizers, pesticides, mechanization, and high-yield crop varieties.	Emphasis on the combination of innovative technologies and eco-friendly agricultural practices, including precision agriculture, ecological agriculture and agricultural biotechnology
Environmental impact	Caused environmental pollution, soil degradation, groundwater contamination and other problems	Focus on reducing environmental pollution, promoting ecological diversity, avoiding over-reliance on chemicals and resource consumption
Resource utilization efficiency	Increased agricultural production, but accompanied by high resource consumption	Enhance the efficiency of resource use, minimize resource wastage and lessen the environmental impact
Production model	Depends on a single high-yield crop and intensive production methods	Support diversified production models, including eco-friendly practices such as crop rotation and integrated farming
Social impact	Increased food production, but may not improve the income and poverty of small farmers	Focus on poverty reduction, emphasize improving rural economy and agricultural equity
Sustainability	Confronted with the depletion of resources, environmental damage, and the loss of biodiversity	Emphasis is placed on sustainable development to guarantee the equilibrium between agriculture and environmental as well as social goals
Food security	Increasing food availability through higher yields, but without addressing poverty and inequality	Emphasize the equitable distribution of food, while ensuring long-term food security and environmental sustainability.

Source: Organized by the author

It is clear from the analysis in the table that sustainable intensification (SI) combines innovative and eco-friendly practices, such as precision agriculture and diversified farming systems, and that SI addresses the environmental and social challenges associated with traditional agricultural maintaining environmental sustainability amidst global challenges like climate change, resource depletion, and population growth [206].

5. SDGs and systemic change (2015-present). The Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs), which were set up by the United Nations, represent a set of significant international development frameworks created to tackle the numerous challenges of global poverty, inequality, and underdevelopment within the context of globalization [212]. The establishment of this framework signaled a major effort by the international community to promote sustainable development and improve human living conditions.

To date, there is no globally recognized definition of food security. This is because food security has been understood differently across various historical periods, countries, regions, socio-economic development levels, and individual perspectives. From 1972 to 1974, global food shortages due to statistical climatic conditions forced an impending food crisis to erupt worldwide, bringing about severe food shortages especially in the least affluent African countries and numerous developing countries [15]. Simultaneously, the major food-producing countries took the lead. during the World Food Conference, the World Declaration on the Elimination of Hunger and Malnutrition and the International Agreement on Global Food Security were approved, which set targets for countries to act on, requiring governments to set a minimum of 18% of food consumption for the year [183]. The Conference defined food security as "ensuring that everyone in the world has access at all times to enough food to be healthy and to survive." This definition places special emphasis on food production-centered development, recognizing the need to prioritize the satisfaction of people's basic food needs, ensure a stable food supply and increase food reserves [93].

Food security, as a fundamental concern linked to national welfare and social cohesion, has a direct impact on both individual well-being and the sustainable development of a nation's economy and society. Starting from the definition of food security and its multidimensional connotation, this paper will systematically explore its specific performance and challenges in the four key areas of supply, access, utilization and stability (Fig. 1.6)

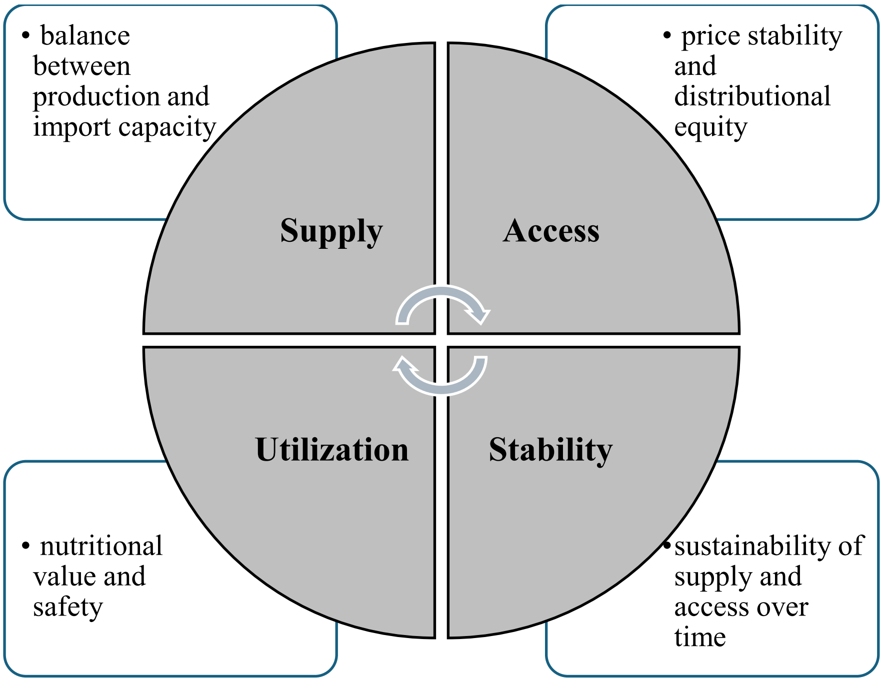


Fig. 1.6. Parameters of Food Security

Source: Organized by the author

Food supply is the cornerstone of food security, and its adequacy directly determines the extent to which people's basic needs are met. The capacity of food production is decided by the accessibility of natural resources, the extent of scientific and technological progress, and the level of policy support [215]. Although China benefits from advanced agricultural technology and effective resource management, challenges such as population increase, reducing arable land, and climate change keep imposing continuous pressure on food production. Simultaneously, as an important means of supplementing domestic production shortfalls, the stabilization of import capacity is crucial. However, overdependence on the international market could pose potential risks. Therefore, improving domestic production capacity and ensuring the diversification of import channels are key to ensuring the security of food supply [220].

The core of food access lies in the capacity of individuals to obtain the food they need at a reasonable cost. The variation in food prices is affected by multiple factors, like the dynamics of market supply and demand, policy interferences, and changes in international markets, and it may potentially endanger food security. Moreover, the fairness of food distribution directly affects social stability and the well-being of individuals [121]. Equitable food distribution contributes to poverty reduction, while inequitable distribution may cause social conflict and threaten food security.

Food utilization involves not only meeting basic living needs, but also enhancing the nutritional quality and safety of food. The nutritional quality of food directly influences the health status of individuals, while safety is related to whether food contains harmful substances during production, processing and consumption. By strengthening food safety supervision and optimizing production processes, the nutrition and safety of food can be effectively safeguarded and people's diets protected [130].

Food stability emphasizes long-term supply and access sustainability. Supply stability relies on continuous improvement of production capacity, diversification of import channels and stability of domestic and foreign markets; while access stability is closely related to price volatility, policy regulation and social stability. To achieve long-term food supply stability, a complete food security system needs to be built from multiple dimensions, including policy, technology and market [32].

In conclusion, food security is a complex system covering four dimensions: supply, access, utilization and stability. Only through a comprehensive enhancement of capabilities in these areas can we effectively secure the basic needs of the population and provide strong support for the sustained development of the national economy and society.

The Fig. 1.7 illustrates the percentage of individuals facing moderate or severe food insecurity across various regions in 2017, 2020, and 2022. The data are expressed as a percentage and are organized by geographic region. The graph illustrates the rise in global food insecurity between 2017 and 2022, showing the largest increase in Africa. Latin America and the Caribbean experienced an increase by 2020, followed by a slight improvement by 2022. The proportion of the global population that is food insecure has also steadily increased, while North America and Europe have seen the least change and have relatively low levels of food insecurity compared to other regions [222]. Food security is not just tied to the survival and well-being of individuals but also serves as a foundation for social stability, economic development and international peace. Food insecurity can lead to malnutrition and increased disease, and can also exacerbate social inequalities, trigger social unrest and migration, and further threaten regional and even global stability [25].

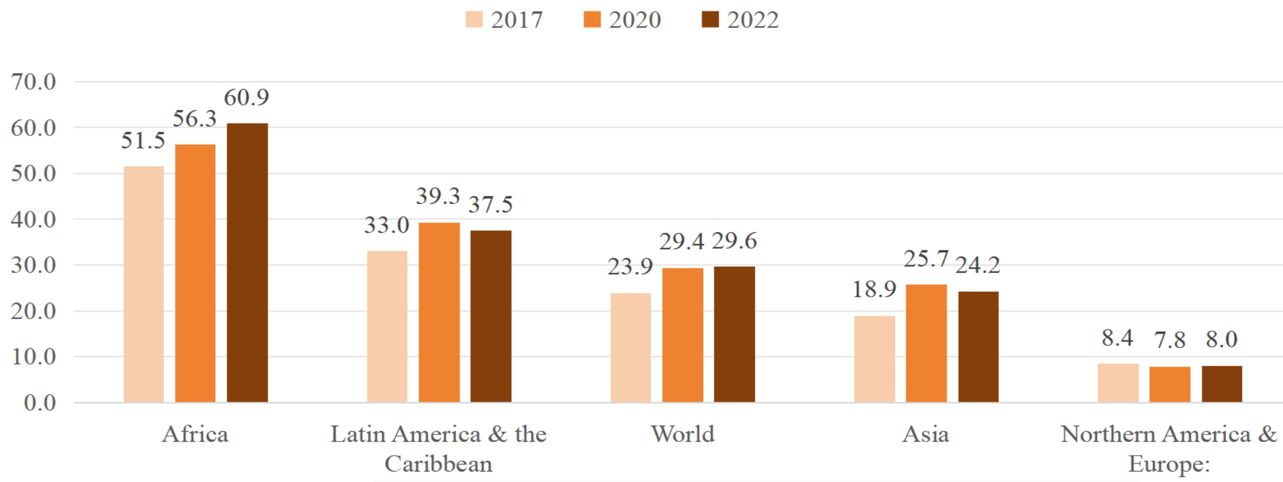


Fig. 1.7. Global progress in reducing hunger (2017-2022)

Source: [222]

Global food security, a complex and multifaceted challenge, is intrinsically linked to the international development agenda and is prominently embodied. The MDGs have an indirect influence on agricultural development and carry significant implications for enhancing food security and alleviating poverty:

Goal 1: Eradicate extreme poverty and hunger. Increasing agricultural productivity has the potential to decrease the number of people suffering from hunger by 50%., ensuring food availability and supporting rural livelihoods [198].

Goal 7 Ensure environmental sustainability. Promote sustainable agricultural practices and reverse the loss of environmental resources. Improve agricultural access to safe water and irrigation [21].

Goal 8: Establish a global partnership for development. Strengthen Cooperation between countries to improve access to agricultural technology and support rural development in LDCs [29].

Addressing food insecurity, poverty and environmental sustainability play a central role in achieving these goals, underscoring their importance in global development strategies.

Sustainable development objectives underscore agriculture's pivotal role in attaining global development targets by enhancing food security, promoting sustainable farming methods, and bolstering climate resilience (Table 1.15).

The historical evolution of global food security has gone through the high degree of natural dependence during the pre-industrialization period, resource plunder during the industrial colonial era, technological unilateralism during the Green Revolution and free trade and ecological awakening during the globalization stage, and has gradually formed a multidimensional global agricultural governance system. In this system, the main typical countries differentiated based on historical path dependence and global competition needs have their strategies for internationalization of agriculture, reflecting the multiple subjects of the global agricultural governance system.

Table 1.15

Sustainable development goals related to agricultural development, food security and environmental sustainability

Objectives	Specific practices in agriculture
Goal 2. End Hunger	Guarantee that everyone, particularly the underprivileged and at-risk groups, has continuous access to adequate, nutritious food throughout the year. Additionally, encourage sustainable farming methods that boost productivity, raise incomes, and enhance resilience while protecting environmental health.
Goal 8. Decent Work and Economic Growth	Enhance agricultural development to create more employment opportunities in rural areas and boost incomes for smallholder farmers.
Goal 12. Responsible Consumption and Production	Promote sustainable agricultural production systems, reduce food waste, and increase the efficiency of resource use in agriculture, including water, land, and energy.
Goal 13. Climate Action	Help the agricultural sector to adapt to climate change through promoting climate-intelligent agriculture and sustainable practices that reduce emissions and improve resilience.
Goal 15. Life and Land	Ensure that agriculture contributes to land restoration, promotes sustainable land management, and prevents land degradation. Encourage sustainable farming practices that protect biodiversity and ecosystem services [221].

Source: systematized by the author

The United States is marked by supply chain leadership and technological innovation. Trade policy and market expansion: The United States has enhanced its agricultural export competitiveness through multilateral trade deals, which lowered tariff barriers and boosted exports of crops such as corn and soybeans [19]. In 2022, U.S. agricultural exports will total $213 billion, accounting for a global market share of 11.3 percent. Within the framework of the WTO, the United States supports the decrease in agricultural subsidies, but circumvents the restriction through the "green box policy", with its total agricultural subsidies amounting to $46 billion in 2021, of which 80 per cent goes to large-scale farms [6].

GM technology dominates globally, with 94% of soybean cultivation in Brazil relying on GM seeds licensed by US firms (2020 data). Transnational grain merchants such as ADM and Cargill control 75% of global grain trade, influencing price volatility through futures markets. Food aid programs are combined with geostrategy, requiring recipients to purchase U.S. farm products, and 30% of aid to Africa in 2021 comes with technology bundling provisions. The United States allocates 40 percent of its corn output toward ethanol fuel production, which raises international food prices and exacerbates the pressure on developing countries' access to food [168].

In the EU, the accent is made on green standards and regional protection. Agricultural policy transformation within the Common Agricultural Policy of the EU (CAP) allocates 25% of its 2021-2027 budget to support eco-agricultural practices, boosting the share of organic acreage to 9.6% (2022 data). Geographical Indication (GI) system protects local specialty products and strengthens brand competitiveness through WTO IP rules, accounting for 55% of global GI products [12]. Strict pesticide residue standards imposed by the EU (50% more stringent than international standards) increase the cost of exports to developing countries by about 20% (World Bank estimates). Through the EU-Africa Green Energy Initiative (AGEI), EUR 5 billion was invested to promote European agricultural technologies in exchange for access to African markets and to increase regional influence [99]. Proposed inclusion of agriculture in the Carbon Boundary Adjustment Mechanism (CBAM), tariffs on high-carbon emitting agricultural products, and forcing Latin America and other regions to adopt low-carbon technologies [28].

Japan is characterized by high value-added orientation and resource security. Japan focuses on promoting high-value agricultural products, such as wagyu beef and high-end fruits, with agricultural exports reaching 1.4 trillion yen by 2022 and wagyu beef exports growing by 30%. Enhancement of product premiums through cultural export, e.g., 400% increase in global consumption of sake in 10 years, government-sponsored overseas training in brewing techniques [127]. Technical cooperation and control of overseas resources: rice cultivation technology is exported to Southeast Asian countries, such as Vietnam's "Koshihikari Rice" project, in exchange for a share of rice imports [126]. The scope of corporate investment in foreign agriculture has grown, as evidenced by Mitsui owning 1.2 million hectares of soybean farms in Brazil, which ensures 70% of Japan's domestic soybean supply [54].

As shown in the Table 1.16, While the agricultural internationalization strategies follow different approaches, they all emphasize technological supremacy, rule-making power and capital penetration to strengthen their global competitive advantages. The U.S. relies on supply chain and technological hegemony, the EU builds barriers with the help of green standards, and Japan concentrates on exporting high-value-added products, which together increase the structural dependence of developing countries on technology and markets. In the future, global agricultural governance needs to break the monopoly framework, promote the innovation of multilateral cooperation mechanisms, and balance the goals of efficiency, equity and sustainability.

Table 1.16

Comparative Differences in Internationalization Strategies

Dimension	United States of America	EU	Japan
Strategic core	Supply chain control and technopoly	Ecological standards and regional protection	High value-added products and resource security
Key instruments	FTAs, genetically modified technology	Agricultural subsidies, geographical indications	Technical cooperation, overseas investment
Food security logic	Pricing power dominance in global markets	Internal requirements and external standard outputs	Import diversification and technology substitution
International contradiction	Competing with the EU for market share in Africa	Counteracting U.S. technology dumping	Balancing CPTPP Openness and Industry Protection

Source: systematized by the author

The development of Chinese agriculture can be categorized into four primary stages (Fig. 1.8), each of which embodies technological progress and significant changes in production methods. In the initial phase of agricultural development, manpower was the main dependency for production, and agricultural activities were highly dependent on, and negated by, natural conditions that reduced productivity and uncertainty. This period was known as the era of manual labor, with relatively primitive agricultural technology and limited productive capacity.

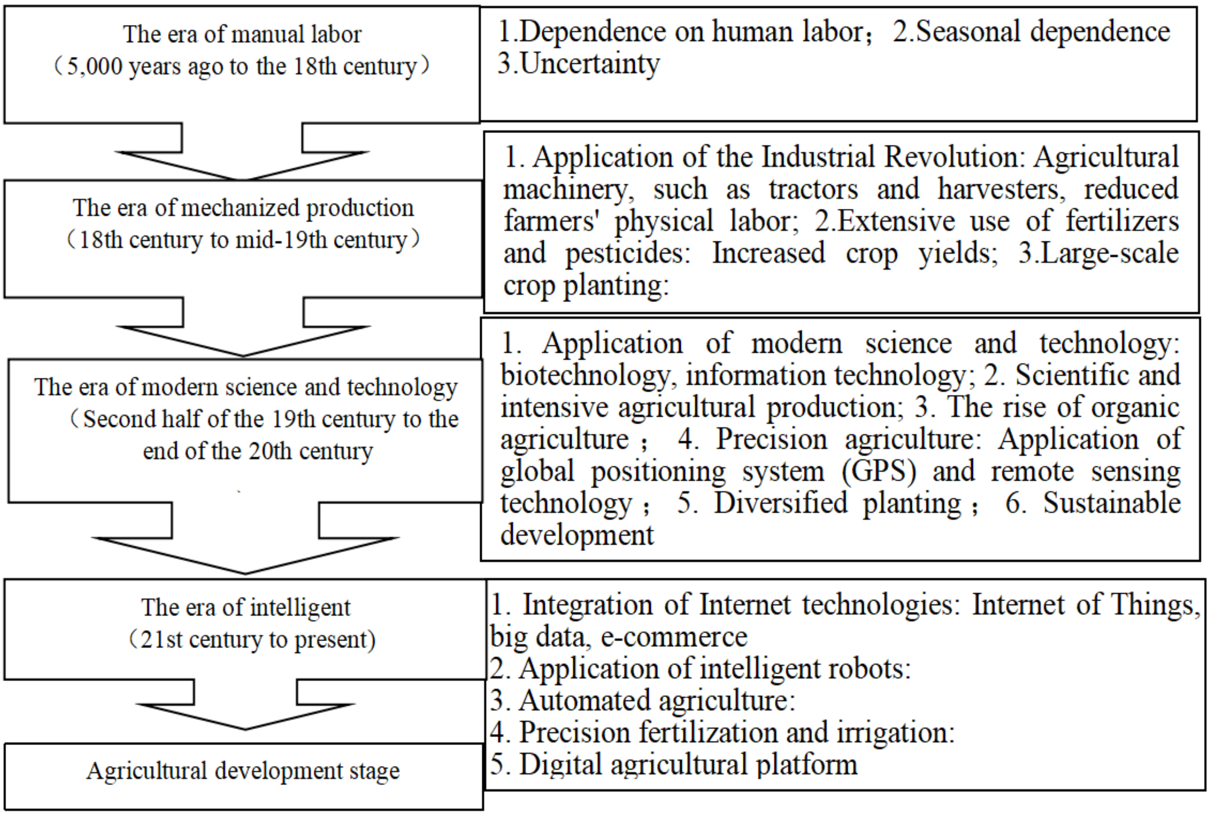


Fig. 1.8 The agricultural development stages in China

Source: systematized by the author

During the 18th and the middle of the 19th centuries, the Industrial Revolution brought about considerable changes in agriculture, marking the beginning of highly mechanized production. With the application of mechanical equipment such as tractors and harvesters, and the spread of agrochemicals such as fertilizers and pesticides, agricultural production capacity was greatly enhanced. The popularization of mechanization made large-scale agriculture possible, and agricultural efficiency and production increased significantly. The transition from the 19th to the 20th century was a key stage in the advancement of agriculture propelled by contemporary scientific and technological innovations. Agriculture in this period was characterized by the application of modern biotechnology, precision agriculture and sustainable development practices. Advances in biological breeding technology, the promotion of scientific planting methods environmental agriculture-type agriculture and the emphasis on environmental agriculture further enhanced the scientific and sustainable nature of agricultural production.

Entering the 21st century, agricultural development has entered the automation stage. The current stage is conspicuously characterized by the extensive application of information technology, including the Internet of Things, big data analysis, automated systems and digital platforms and other shells of technology. The advancement of smart agriculture has significantly enhanced the precision and efficiency of agricultural production, realizing the transformation from a labor-intensive model to a highly automated, technology-driven agriculture. The process of agrarianization not only reflects the continuous progress of agricultural technology, but also agriculture's ability to adapt to sustainable development and the globalization of demand within the context of the new era.

Table 1.17 illustrates a substantial change in the structure of China's agricultural industry from the pre-1980 era to the post-2000 era, and highlights trends in the changing importance of various agricultural subsectors. During the traditional agricultural phase (pre-1980), grain production was at the core of agriculture, contributing about 80 percent of total agricultural output. However, the share of food in agriculture declined significantly to 40% after 2000, mainly due to the shift in Chinese agriculture from traditional food crop production to horticulture; the horticulture sector (including fruits, vegetables and flowers) has shown strong growth, prior to 1980, the sector contributed just 10% to the total value of agricultural output, but with sales increasing to 30% after 2000, reflecting the modernization of the horticulture sector and the increasing demand for high-value crops (especially in the domestic market) [240].

Table 1.17

Structural Changes in China's Major Agricultural Sectors (2020)

Sector	Traditional (pre-1980)	Modern (post-2000)
maize	80%	40%
horticulture	10%	30%
aquaculture	2%	15%
herds	8%	15%
others		10%

Source: Data adapted from National Statistical Office, 2020

The growth of aquaculture has been extremely significant, accounting for 2% of GDP before 1980. After 2000, the sector's share of agriculture jumped to 15 percent, making China an important global leader in aquaculture and the production of fish and seafood products. The livestock sector has also shown rapid growth, from 8 percent before 1980 to 15 percent after 2000, a change that reflects rising domestic and global demand for consumer meat and animal protein. This category "Others" is hardly visible in traditional agriculture and it covers 10% of the agricultural sector after 2000. This may include some emerging agricultural industries such as specialty crops, agro-processing, and bioenergy production, showing the exciting transformation of China's agricultural sector. Overall, this changing trend reflects the modernization, marketization and internationalization of Chinese agriculture, especially in the development of industries that support exports and high value-added products, leading to a profound restructuring of the agricultural industry.

Table 1.18 analyses how China's agricultural sector is adapting more effectively to changing demand trends as it modernizes. While rice and wheat remain the core crops for ensuring the country's food security, their relative position in the overall agricultural structure has been revitalized by the emphasis on higher-value-added industries such as horticulture, animal husbandry and aquaculture.

Table 1.18

Key factors in the modernization of China's agricultural sector

Key aspects	Characteristics
Core crops	Rice and wheat remain core crops for ensuring national food security, but their relative position in the overall agricultural structure has declined.
High value-added industries	The greater emphasis placed on high value-added industries like horticulture, animal husbandry and aquaculture is in line with middle-class consumer preferences and export demand.
Technological advancement	The widespread use of mechanization, variety improvement and biotechnology seeds has significantly improved production efficiency and production capacity.
Production efficiency	Technological advances have significantly increased crop yields and reduced reliance on human labor.
Aquaculture	Aquaculture has become a key industry, cementing China's position as a major global seafood exporter.
Policy Adjustment	Policy adjustments and technological advances have helped China successfully cope with the dual challenges of feeding its population and competing in the international agricultural market.
Consumer Preferences	Emerging industries have significantly contributed to addressing the preferences of middle-class consumers.
Export revenue	High value-added industries have had a significant impact on increasing export revenue.

Source: Organized by the author based on [147]

These emerging industries have not only been crucial in catering to the consumer preferences of a growing middle class but have also substantially contributed to increasing export revenues. At the heart of this reform has been technological progress, which has contributed to significant improvements in production efficiency and productivity across industries. The drive for mechanization, improved varieties, and the widespread use of biotech seeds have substantially increased crop yields and, to some extent, reduced the dependence on human labor. Meanwhile, aquaculture, a key industry, has become an important asset for China, further solidifying its status as the foremost seafood exporter globally. This series of developments exemplifies how China has capitalized on policy adjustments and technological advances to successfully meet the dual challenge of feeding its population and competing in international agricultural markets.

Over the past several decades, the international agricultural strategy of China has undergone a remarkable transformation (Table 1.19). Initially centered on achieving domestic self-sufficiency, it has gradually developed to assume a more significant role in the global agricultural market. Following the implementation of the reform and opening-up policies, the implementation of the household contract responsibility system significantly improved agricultural productivity, tackled food security issues, and met the demand resulting from rapid population growth [136].

Table 1.19

International Dimensions of China's Agricultural Strategy

Period	Key Focus	Key Policies
1980s-1990s	Domestic food security, productivity	Household Responsibility System, grain reserves
2000s	Global trade integration, food imports	WTO accession, strategic grain imports
2010s- Present	Internationalization, global agricultural influence	Belt and Road Initiative (BRI), overseas projects

Source: systematized by the author

Entering the 21st century, China has further integrated into the global agricultural trade system through its entry into the WTO, and become a major importer of soybeans, grains and livestock products. Simultaneously, China has prioritized domestic food security as a key policy focus, highlighting the significance of strategic grain reserves. The Belt and Road Initiative, introduced in 2013, has further strengthened China's influence in the global agricultural sector. It had improved food supply chains and market access in Africa, Asia and Latin America through infrastructure investment, technical cooperation and trade networking. In addition, China's investments in overseas agricultural projects aim to ensure the stability of food imports and the diversification of supply sources. These strategic adjustments not only reflect China's continued focus on agricultural development, but also highlight its growing role and influence in the global food security landscape [239].

The table reveals significant changes in China's agricultural strategy and its policy priorities at different stages. From the 1980s to the 1990s, China made ensuring domestic food security and increasing agricultural productivity its core objectives. Concurrently, a grain reserve system was developed to safeguard food security. Entering the twenty-first century, the policy focus shifted to global trade integration as domestic demand grew. In particular, since China joined the WTO in 2001, its agricultural markets have been gradually opened up and strengthened strategic food imports to meet domestic demand. From 2010 to the present, China's agricultural strategy has become more internationalized, with the BRI, launched in 2013, at its core, enhancing global agricultural influence through investment in overseas agricultural infrastructure and trade routes. Simultaneously, China is actively participating in international agricultural projects to ensure a diversified food supply and enhance its global competitiveness. This evolution clearly demonstrates China's strategic shift from domestic food security to global market integration, reflecting its increasingly important role in the global agricultural landscape [150].

In the global agricultural governance system, a complex network of multilateral institutions, national strategies, and market forces is in place. Global organizations like the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), and the World Bank are crucial in advancing sustainable agricultural growth and combating hunger worldwide (Table 1.20) [31].

Table 1.20

Contributions of international organizations in promoting the internationalization of Chinese agriculture

Organization	Main contributions	Contributing results and typical evidence
Food and Agriculture Organization of the United Nations	Developing global standards and guidelines for sustainable agriculture	95% of member countries adopt FAO Guidelines for Sustainable Agriculture (e.g., Climate-Smart Agricultural Sourcebook). 19 countries in Africa certified to FAO standards to reduce pesticide use by 30% (2015-2020).
	Technical assistance and capacity-building	Assisted Ethiopia to develop a National Food Security Strategy (2016) covering 10 million people and a 12% reduction in food insecurity (2016-2021). Scaling up Rice Intensification (SRI) technology in Southeast Asia with 25% higher yields (Indonesia case, 2018).
	Knowledge dissemination and policy implications	The Global Conference on Family Farming led to the signing of a Ten-Year Plan of Action (2019) by 25 countries to promote ecological farming practices. Brazil's Zero Hunger Program, which draws on the FAO framework, has reduced malnutrition from 10 percent (2003) to 2.5 percent (2014).
WTO (World Trade Organization)	Trade rule-making and market opening	Agreement on Agriculture (1995) cuts global agricultural tariffs by 37%, but "green box" subsidies in developed countries exceed $400 billion annually (OECD data). Export revenues of four West African countries increased by 18% (2006-2010) when the 2005 cotton dispute ruled that US subsidies had been violated
	Dispute settlement and technical barrier harmonization	EU ruled out of compliance by WTO over CAP eco-subsidies (Case 2021), forcing policy adjustments. Harmonize tariff quotas for Japanese rice (777,000 tons per year) to balance market access and industry protection.
International Fund for Agricultural Development	Smallholder empowerment and inclusive development	Supporting 100,000 herders in Mongolia to improve grassland management and increase livestock income by 40% (2015-2020) Raised $500 million through a public-private partnership (PPP) in India to build rural cold chain facilities and reduce fruit and vegetable losses by 35%.
	Promotion of sustainable technologies	One million farmers in Africa's Sahel region trained in drought-tolerant crops to increase maize yields by 50 percent (2017-2022) 50,000 farmers in Peru adopt IFAD-recommended quinoa rotation technique and land degradation rate drops by 20%.
World Bank	Agricultural project finance and policy support	US$300 million project in the Mekong Delta, Vietnam (2010-2020) to increase rice yields by 30%, benefiting 2 million people. Indian policy advice drives 20% growth in wheat production (Punjab case, 2005-2015).
	Investment in rural infrastructure	Bangladesh Rural Roads Project (2015-2022) covers 1.5 million people, reduces transportation costs by 40%, and increases market access by 60%. Irrigation projects in Ethiopia add 120,000 hectares of arable land and double cereal production (2018)
	Engaging in global dialogues and partnerships to address food security challenges	Promoting international partnerships in more than 50 initiatives (co-hosted the Global Summit on Food Security, with commitments from 40 countries).

Source: Organized by the author

FAO supports countries in improving agricultural productivity and addressing climate change through technical assistance, data analysis and policy guidance, with the Global Food Security Program and the Smart Agroclimate Project being important initiatives. The WTO promotes trade liberalization and the compatibility of trade equity and sustainability through trade rulemaking and market opening, while coordinating dispute settlement and technical barriers.

IFAD focuses on reducing rural poverty by investing in smallholder economies and improving infrastructure, providing markets, resources and technical support to marginalized areas, and increasing the sustainability and productivity of agriculture.

The World Bank promotes agricultural productivity, market access and climate change adaptation through financial and technical support, and the Global Agriculture and Food Security Program of it offers significant support to countries.

The synergic cooperation of these organizations not only promotes agricultural technological innovation and optimal allocation of resources, but also provides an effective model of cooperation for global food security, laying a solid foundation for solving the food crisis and achieving the goals of sustainable development.

Conclusions to chapter 1

Agriculture, being the cornerstone of human civilization, is confronted by challenges such as population growth, climate change, and resource shortage. From an ontological point of view, agriculture is not only a material production activity, but also a complex phenomenon in the socio-ecological system, which is affected by multiple natural and social factors. The development of agriculture has passed through four phases: primitive agriculture, traditional agriculture, modern agriculture and contemporary agriculture, with each change driving a leap in productivity and a transformation of human lifestyles. In order to ensure global food security, maintain ecological balance and address climate change, the transformation of agriculture must adhere to the path of sustainable development.

Sustainable agricultural development represents a deeper advancement in the progression of agriculture, emphasizing a balance between the economy, society and the environment. Sustainable agricultural systems differ substantially from traditional agriculture in terms of concepts, technologies, goals, and practices, placing greater importance on preserving the long-term health of agricultural ecosystems. Promoting sustainable agriculture is key to harmonizing food production with environmental protection, and its core principles include environmental sustainability, economic viability, social equity and policy governance.

The internationalization of agriculture refers to the transnational flow of factors such as agricultural production, trade, investment and technology, forming global industrial chains and market networks. Its core lies in optimizing the allocation of agricultural resources and improving the efficiency of the global food system through transnational cooperation and resource integration. Its theoretical basis includes the theory of comparative advantage, the theory of global value chains, the theory of the food sovereignty model, the theory of factor endowments and the theory of agricultural globalization.

Agricultural progress is driven by technological innovation and the internationalization of agricultural distribution, While population pressure acts as a core driving force for agricultural progress and technological innovation. Key dimensions of agricultural progress include five aspects: technological innovation, productivity improvement, environmental protection, economic optimization and policy support.

Global agricultural development has gone through phases of pre-industrialization, the industrial revolution and colonial agriculture, the green revolution, the nascent period of sustainable intensification, and the SDGs and systemic change. Each phase has its own specific agricultural strategies and policies, reflecting the intertwined technological, political, ecological and social evolution [76].

International organizations play a crucial role in promoting sustainable global agricultural development and reducing hunger. These organizations support countries in developing their agriculture through technical assistance, policy guidance, trade rule-setting and project financing.

During the period from the 1980s to the 1990s, China's agricultural strategy was centered on domestic food security, increasing agricultural productivity, and then shifted to the integration of global trade in the 21st century, and has become even more internationalized since 2010, with the "One Belt, One Road" Initiative and investment in overseas projects to enhance the global impact of agriculture. (d) Increasing global agricultural influence through the "Belt and Road" initiative and investment in overseas projects.

The results of the Chapter 1 are summarized in author’s papers: [66, 70, 71, 73].

CHAPTER 2.
ANALYSIS OF INTERNATIONALIZATION PROCESS IN CHINA'S AGRICULTURE

2.1. Sectoral and Geographical Pattern of Chinese Agriculture

Agriculture in China serves as a key pillar of the national economy, and its advancement is vital for both domestic economic expansion and fulfilling the basic nutritional needs of the population. Compared with other countries around the globe, Chinese agriculture has distinct characteristics. Firstly, the availability of arable land resources is limited. According to the Main Data Bulletin of the Third National Land Survey, China's arable land encompasses an area of 1.918 billion mu, of which 471 million mu, or 24.55 per cent, are paddy fields, 481 million mu, or 25.12 per cent, are watered land, and 965 million mu, or 50.33 per cent, are dry land. 64 per cent of the arable land is located to the north of the Qinling-Huai River. The per capita area of arable land is only about 0.10 hectares, far below the global average, which exacerbates the pressure on agricultural production. The quality of China's arable land varies widely, with problems such as low soil fertility and serious soil erosion, making agricultural production a major challenge [14].

Secondly, the regional distribution of agricultural production is uneven. Chinese agriculture is influenced by both natural and socio-economic factors, with the eastern region of the country is characterized by advanced agricultural development, while the western region remains comparatively underdeveloped. In particular, the climatic differences between the north and the south have led to significant differences in the cropping patterns of different crops and in agricultural technology. For example, the south is suitable for the cultivation of rice and sugar cane, while the north is dominated by wheat and maize.

Thirdly, considerable disparities exist in crop structures between the South and the North. There are notable differences in agricultural production conditions and patterns between the South and the North. The climate in the South is humid and suitable for the cultivation of crops, while the climate in the North is dry and appropriate for the cultivation of crops. This difference has led to differences between the South and the North in terms of the types of crops, cropping systems, agricultural technology, and so on [132].

To analyze the arrangement of agricultural activity among Chinese provinces, we use hierarchical clustering with the Euclidean distance metric to measure the similarity between provinces. The Ward's linkage method was applied to minimize variance within clusters.

The dataset consists of several key indicators for 31 Chinese provinces. The data was compiled from publicly available economic and demographic reports of the National Bureau of Statistics of China (NBS of China) for 2023. The analysis is conducted in two stages:

1.The pattern of Chinese provinces according to economic and demographic indicators.

2.The pattern of provinces according to the type of agricultural output.

The first survey is based on the following indicators: urban population, rural population, regional GDP, agrarian output or value added, total value of exports and total value of imports.

The relevant structured information on regional agricultural pattern is rather limited or outdated. For the second survey we will use such indicators: gross output value of agriculture (growing crops), gross output value of forestry, gross output value of animal husbandry and gross output value of fishery.

To prevent variables with large numeric ranges (e.g., GDP) from dominating the clustering process, all data was normalized using Z-score normalization:

$$\mathrm{Z} = \frac{\mathrm{X} - \mu}{\sigma}$$

Where X represents the original value, μ stands for the mean, and σ indicates the standard deviation.

A dendrogram was generated to visualize hierarchical relationships among provinces. The height at which clusters merge represents their dissimilarity. Figure 2.1 presents the resulting dendrogram, illustrating the clustering patterns among Chinese provinces, and showcasing the economic and demographic relationships.

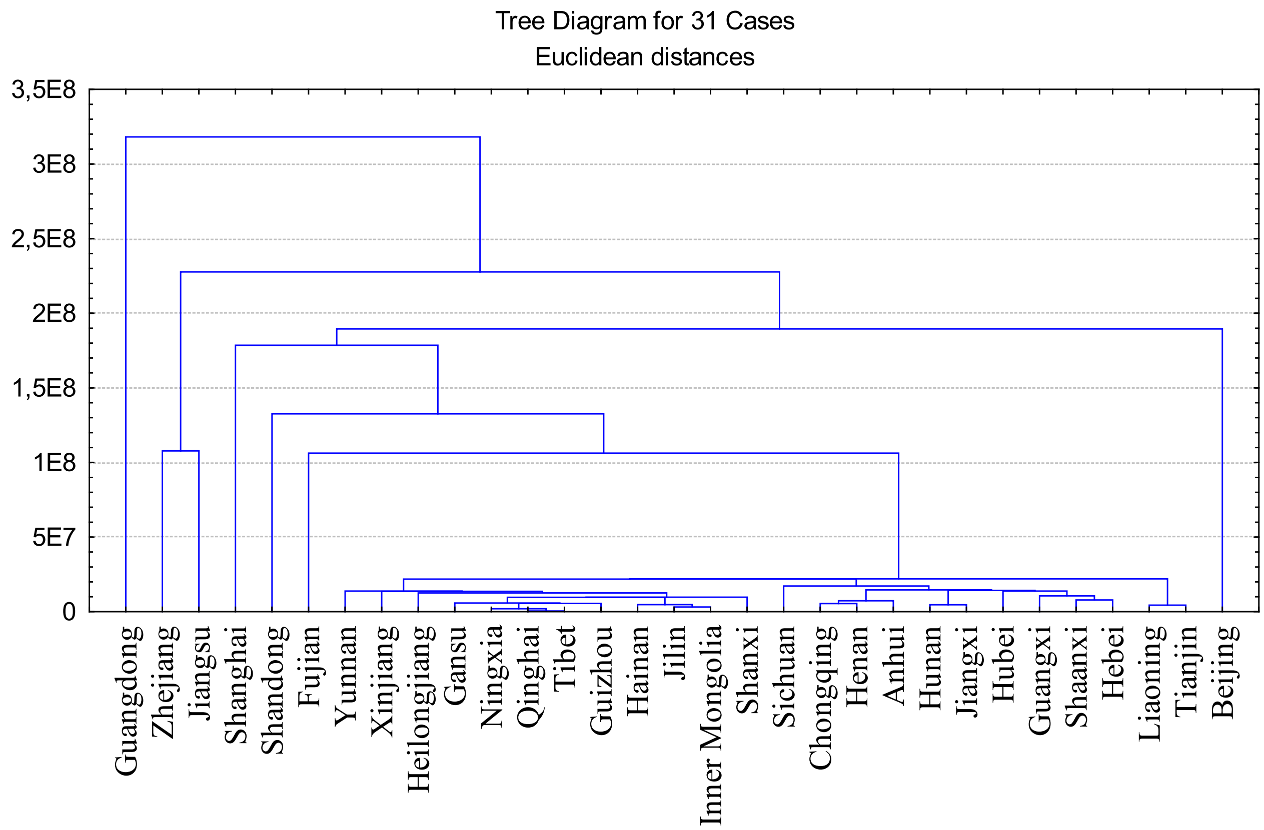


Fig. 2.1. Cluster dendrogram of Chinese provinces based on the structure of economic activity

Source: systematized by the author

The largest distance is observed between Tibet and Guangdong, indicating extreme economic differences. Guangdong and Jiangsu stand out as the most trade-heavy provinces, with the highest export and import values. Provinces with similar agrarian profiles (e.g., Jilin and Inner Mongolia) cluster at shorter distances. Agricultural powerhouses like Heilongjiang, Henan, and Shandong show strong agrarian GDP contributions. Urbanized provinces such as Beijing and Shanghai form a small, distinct subgroup – they are top financial centers but have low agrarian output.

The clustering suggests that Chinese provinces can be broadly categorized into the groups indicated in Table 2.1.

The second stage of research is related to the pattern of agricultural output of Chinese provinces. The results are summarized in Fig. 2.2. Cluster formation analysis of the dendrogram reveals five major clusters:

Table 2.1

Clusters of Chinese provinces according to economic and demographic indicators

Cluster group	Provinces	Characteristics
(A) Highly Developed Economic Centers (Top-tier Cluster)	Beijing, Shanghai, Jiangsu, Guangdong, Zhejiang	• **High Regional GDP** and **urban population** dominance. • Strong trade hubs, with **high export and import** values (Jiangsu and Guangdong lead in trade). • **Low agrarian output**, as these regions focus more on industry and services.
(B) Industrial and Trade-Driven Provinces (Upper-Mid Cluster)	Tianjin, Liaoning, Fujian, Shandong, Chongqing	• Moderate-to-high GDP with significant urbanization. • Strong participation in exports and imports. • **Mid-range agrarian** activity compared to agriculture-heavy regions.
(C) Agrarian-Industrial Hybrid Economies (Middle Cluster)	Hebei, Henan, Anhui, Sichuan, Hubei, Hunan, Guangxi, Jiangxi	• Balance between urban and rural populations. • Significant **agricultural output** alongside industry. • Trade is not as dominant as in the top-tier economic centers.
(D) Agriculture-Dominant & Developing Regions (Lower-Mid Cluster)	Heilongjiang, Jilin, Inner Mongolia, Shanxi, Xinjiang, Guizhou, Yunnan, Shaanxi	• High **agrarian output** relative to GDP. • Rural population share is higher than in industrialized provinces. • Less integration in **global trade** (lower export/import values).
(E) Least Developed & Remote Regions (Bottom-tier Cluster)	Tibet, Qinghai, Ningxia, Gansu, Hainan	• Low GDP and economic output. • Limited trade activity. • Small population and **geographically isolated**.

Source: systematized by the author

1. Highly agricultural provinces: Henan, Shandong, Heilongjiang – high total agricultural output (crops).

2. Balanced economic provinces: Guangdong, Jiangsu, Zhejiang – strong crops and other agricultural sectors.

3. Low agricultural output provinces: Tibet, Qinghai, Ningxia – limited agricultural activity and economic scale (including such urban provinces as Beijing and Shanghai).

4. Provinces with strong animal husbandry sectors: such as Inner Mongolia and Heilongjiang, that exhibit close clustering.

5. Provinces with significant fishery industries: including Fujian and Guangdong, that form a distinct subgroup.

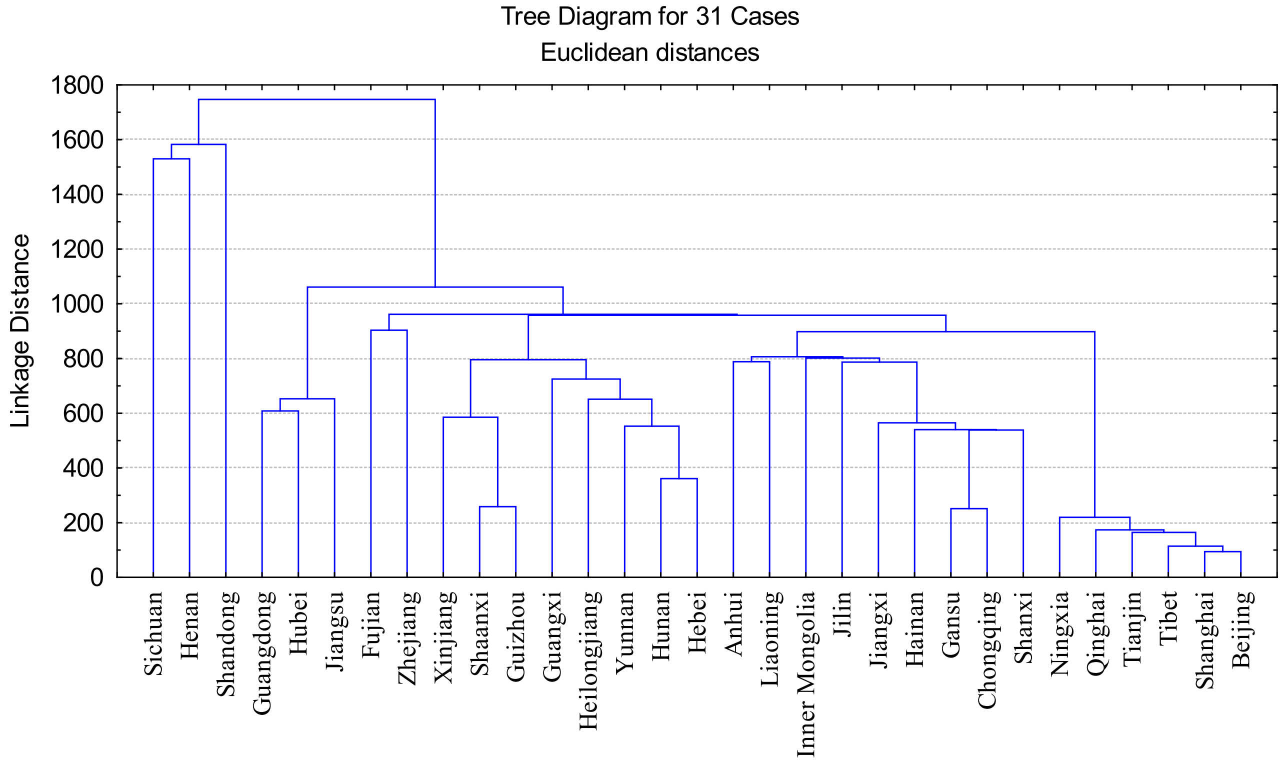


Fig. 2.2. Cluster dendrogram of Chinese provinces based on the pattern of agricultural output

Source: systematized by the author

China's agricultural sector has distinctive features that directly form an agricultural system with specific characteristics. The system covers four core areas: planting, animal husbandry, fisheries and forestry, and these sectors occupy an essential role in the national economy. Cultivation is dominated by grain crops and cash crops; animal husbandry focuses on breeding pigs, cattle, sheep and poultry; fisheries include freshwater aquaculture and marine fishing; and forestry focuses on the sustainable management and utilization of forest resources.

In December 2020, the National Bureau of Statistics of China published the Statistical Classification of Agriculture and Related Industries, which provides a scientific statistical definition of the agricultural sector (Table 2.2). This classification system, combined with international standards, covers the areas of production, processing, manufacturing, distribution, and services related to agriculture, forestry, animal husbandry, and fisheries are outlined. This includes the processing of products derived from these sectors as well as the production of means of production and the construction of water conservancy facilities for farmland. The classification not only supports the development of modern agriculture, but also establishes a theoretical foundation for the execution of the rural revitalization strategy and facilitates the comprehensive advancement of agriculture and its associated industries.

Table 2.2

Statistical Classification of Agricultural and Related Industries in China

Classification Code	National Economy Name	Classification Code	National Economy Name
1	Agriculture, forestry, animal husbandry and fishery	6	Agriculture, forestry, animal husbandry, fishery scientific research and technical services
2	Processing and manufacturing of edible agricultural, forestry, animal husbandry and fishery products	7	Agriculture, forestry, animal husbandry, fishery education training and human resources services
3	Processing and manufacturing of non-edible agricultural, forestry, animal husbandry and fishery products	8	Agriculture, forestry, animal husbandry, fishery ecological protection and environmental governance Management
4	Manufacturing of means of production for agriculture, forestry, animal husbandry and fishery and construction of farmland water conservancy facilities	9	Agriculture, forestry, animal husbandry and fishery leisure and tourism and agricultural and rural management services
5	Agriculture, forestry, animal husbandry, fishery and related product distribution services	10	Other support services

Source: systematized by the author Order No. 32

The three core sectors of cultivation, animal husbandry and fisheries together constitute China's agricultural system, and their spatial distribution shows significant geographical variability (Fig. 2.3).

Rice prefers warmth and humidity and is mainly found in the southern region. North of the Yangtze River is a single-season rice area with a short growing cycle, while double- or triple-season rice is grown in the south, especially in areas such as Hainan. Double-season rice is divided into two growth cycles, early rice and late rice, early rice transplanting at the end of May, July harvest immediately after the late rice planting, until November to complete the harvest. In contrast, single-season rice has only one growth cycle, from transplanting in early June to harvesting in October. The acre yield of single-season rice is higher, but the total yield is lower than that of double-season rice.

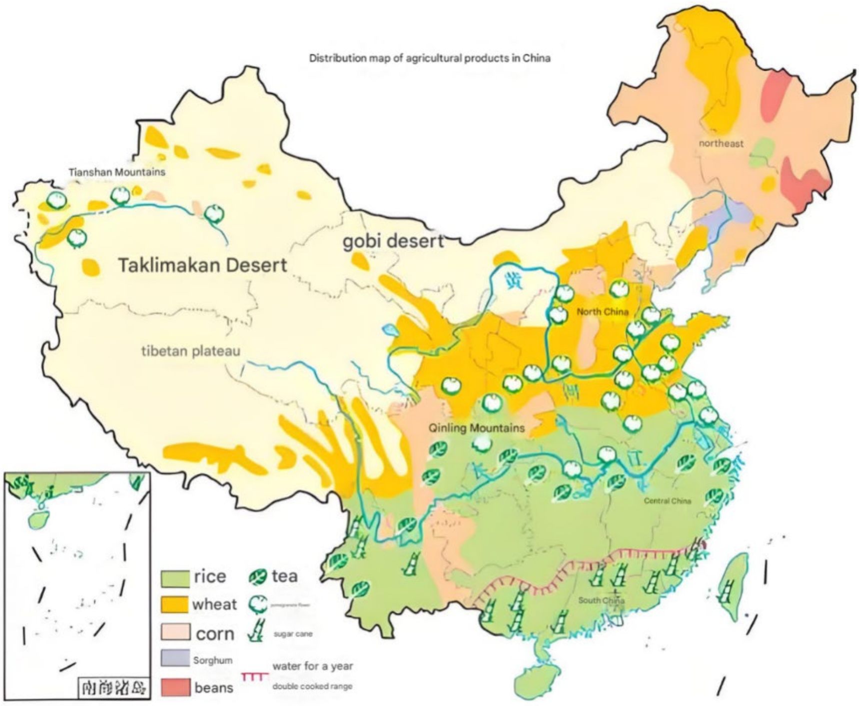


Fig. 2.3. Distribution map of agricultural products in China

Source: Chinese Academy of Agricultural Sciences, CAAS

Wheat is cold- and drought-resistant and widely adapted, and is mainly distributed in northern China, especially between the Qinling-Huai River and the ancient Great Wall. Winter wheat with a long growth cycle of 120 to 330 days, depending on the region. North of the Ancient Great Wall, spring wheat is mainly grown, which has a shorter growth cycle, usually 80 to 120 days.

Corn likes high temperature, needs more water, suitable for growth in loose soil, widely distributed in the Sichuan Basin, Yunnan-Guizhou Plateau, Hebei and Northeast and other regions, especially in the Songnen Plain in the central Northeast, forming China's "corn belt".

Soybean (soybean) a major grain crop originating from China, is extensively cultivated across the country, with the northeast region being the primary production area. Soybean seeds are rich in vegetable protein and are widely used in the processing of soybean products, soybean oil, soy sauce, etc., and are also often used as livestock feed. The origins of soybean cultivation date back approximately five thousand years [145].

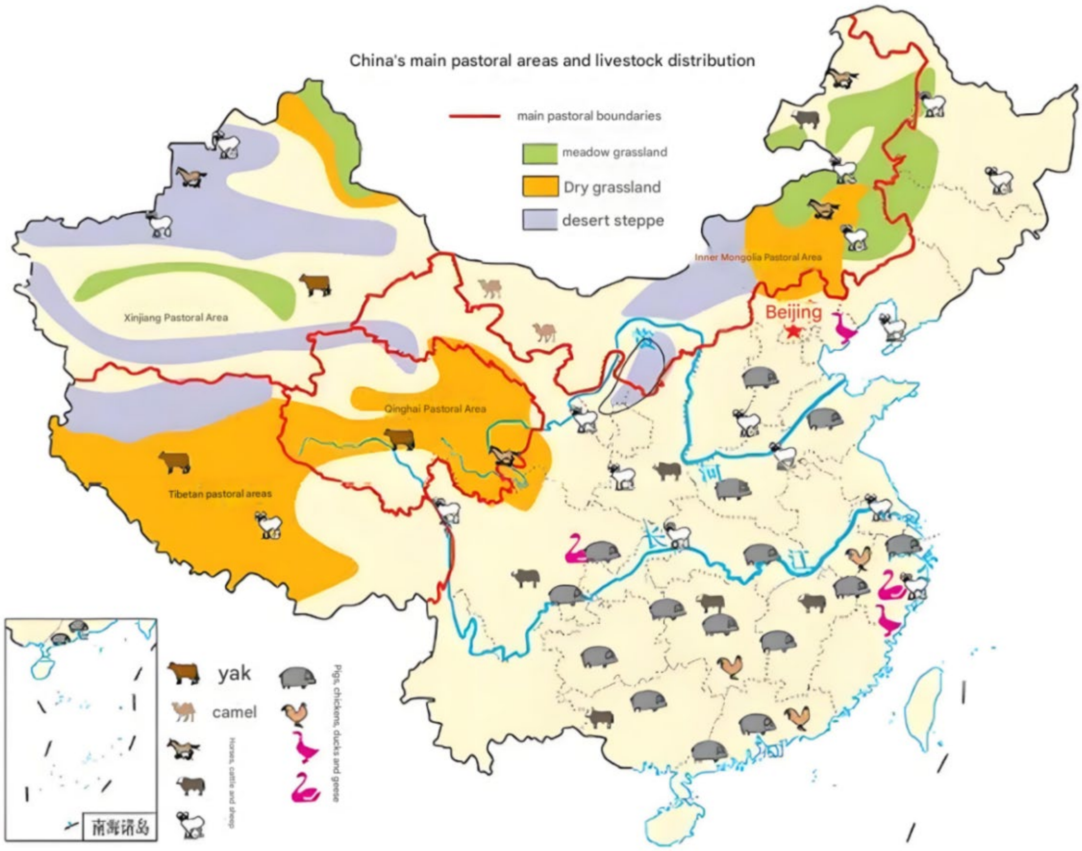


Fig. 2.4. Distribution map of animal husbandry in China

Source: Chinese Academy of Agricultural Sciences, CAAS

Animal husbandry in China's pastoral areas benefits from vast grassland resources, mainly in Qinghai and Tibet (Fig.2.4). The grasslands in this region include temperate grasslands and alpine meadows, dominated by dry, perennial herbaceous plants, which are suitable for breeding Tibetan goats, Tibetan sheep and yaks. Climatic conditions in the pastoral area include temperate grassland climate zones and alpine grasslands, which are particularly suitable for the growth of these livestock. Livestock farming in the farming area, on the other hand, relies on rich feed resources and a broad consumer market, and is mainly located in Sichuan, Hunan and Henan. Major livestock products in the region include chickens, ducks, geese and pigs. With the growth of market demand, the future development of the livestock industry will gradually shift from decentralized rearing by farmers to specialized production to enhance production efficiency and improve product quality.

Fisheries include freshwater aquaculture and marine aquaculture (Fig. 2.5). Depending on the mode of production, it can be further divided into two categories: natural fishing and artificial culture. China holds the leading position globally in the production of aquatic products. China's development of aquatic water conditions are favorable, the land area of rivers and lakes, a long history of breeding; the ocean, from north to south, in turn, The Bohai Sea, the Yellow Sea, the East China Sea, the South China Sea, and various other extensive bodies of water.

Fig. 2.5. Distribution map of China's aquaculture industry

Source: Chinese Academy of Agricultural Sciences, CAAS

As shown in Table 2.3, the China's production characteristics and production areas of major agricultural products. Grain crops are classified as rice, wheat and maize, and their production is characterized by large-scale cultivation and mechanization, which the distribution of these areas encompasses the Northeast Plain, the North China Plain, as well as the Yangtze River Delta and the regions along the middle and lower reaches of the Yangtze River. Cash crops, covering cotton, oil crops such as rape, peanuts, and sugar crops such as sugarcane and sugar beet, are characterized by regionalized cultivation and high value-added production, and are mainly produced in Xinjiang, the Yangtze River Basin, and South China.

Table 2.3

Major Agricultural Product Producing Areas in China

Categori–zation	**Staple**	**Production characteristics**	**Major area**
1	**2**	**3**	**4**
Cereals	Rice, wheat, maize	Large-scale cultivation with high degree of mechanization	The Northeast Plain, the North China Plain, and the plains in the middle and lower reaches of the Yangtze River.
Cash crop (economics)	Cotton, oilseed crops (like rapeseed and peanuts), and sugar crops (such as sugarcane and sugar beets)	Regionalized cultivation with higher added value	Xinjiang (cotton), Yangtze River Basin (oilseed rape), South China (sugarcane)
High-value crops	Fruits, vegetables, tea, nuts	Intensive and refined cultivation with high market demand	Shandong (fruits, vegetables), Fujian (tea), Yunnan (nuts)
Stock raising	Hogs, cattle and sheep, poultry	Large-scale farming coexists with free-range farming	Sichuan (hogs), Inner Mongolia (cattle and sheep), Shandong (poultry)
Aquaculture	Freshwater aquaculture (fish, shrimp), mariculture (shellfish, seaweed)	Technology-intensive, with a clear trend towards ecological farming	Hubei (freshwater fish), Shandong (mariculture), Guangdong (shrimp)
Forestry and specialty agriculture	Timber, forest economy (e.g., mushrooms, medicinal herbs), specialty agricultural products (e.g., wolfberries, peppers)	Eco-efficiency and economic efficiency Simultaneously	Northeast (timber), southwest (forest economy), northwest (specialty agricultural products)

Source: systematized by the author

High-value crops such as fruits, vegetables, tea and nuts are produced by intensive and refined cultivation with high market demand, of which Shandong, Fujian and Yunnan are important places of origin. In terms of animal husbandry, it mainly involves live pigs, cattle and sheep, and poultry, with large-scale farming and free-range farming co-existing, with Sichuan and Inner Mongolia being the main regions. Aquaculture includes freshwater aquaculture of fish and shrimp and seawater aquaculture of shellfish and seaweeds, with technology-intensive development and a clear trend of eco-farming, with Hubei, Shandong, and Guangdong as the key regions. Forestry and specialty agriculture, timber, forest economy such as fungus, medicinal herbs, specialty agricultural products such as wolfberry, pepper production, balancing ecological and economic benefits, distributed in the northeast, southwest, northwest and other places [243].

The formation of is the result of the interaction of a number of factors, including natural conditions, dynamics, agro-environmental, and socio-cultural contexts.

Specifically, climatic elements such as temperature, precipitation, and signal conditions, as well as topographic features and soil types have significantly influenced the crop species grown in each region Additionally, the economy has also significantly contributed to the advancement of agriculture, including an important impetus from market demand for high-value crops, animal husbandry, and aquaculture, the upgrading of technological levels, and policy support, all of which have contributed to the process of regionalization and specialization in agriculture [33]. Simultaneously, socio-cultural factors should not be ignored. Differences in dietary habits (north-south and ethnic characteristics), changes in the distribution of labor, as well as local characteristics and culture embodied in traditional agriculture are intertwined to build the complexity and diversity of China's agrarian geography.

China's agricultural geography shows significant regional differentiation (Table 2.4), and its spatial distribution pattern is highly coupled with the natural geographic conditions and the level of economic development [142]. Relying on superior climatic conditions and location advantages, the eastern coastal region has formed a high value-added agricultural production system represented by facility agriculture, focusing on the development of vegetable and fruit cultivation and aquaculture, and additionally, encouraging the processing of agricultural products for export is crucial, guided by an export-oriented economy.

The central plains region serves as a core area for national food security and is primarily focused on the cultivation of staple grain crops, and has realized large-scale mechanized production relying on the flat topography and fertile soil, and has become the intensive development of modern agriculture. The central plain area, as the core area of national food security, focuses on the cultivation of bulk grain crops , relying on the flat terrain and fertile soil, realizing large-scale mechanized production and becoming a typical representative of the intensive development of modern agriculture; the western plateau area, based on unique natural ecological conditions, develops characteristic agriculture mainly in animal husbandry, Chinese herbal medicine and special fruits and trees, and simultaneously fosters the coordinated advancement of agriculture and the ecological environment through the returning of farmland to forests and the protection of grasslands and other ecological restoration measures, forming a unique ecological agriculture model. This diversified regional agricultural pattern fully embodies the synergy between natural endowments and human activities.

Table 2.4

Agricultural geography in China

Region	Main agricultural types	Geographical features	Representative provinces
Northeast China	Food crops (corn, rice), soybeans	Fertile black soil, high degree of mechanization	Heilongjiang, Jilin, Liaoning
North China	Wheat, corn, cotton	Broad plains, developed irrigation agriculture	Hebei, Henan, Shandong
Middle and Lower Reaches of the Yangtze River	Rice, rapeseed, freshwater aquaculture	Dense water network, humid climate	Jiangsu, Zhejiang, Hubei
South China	Rice, sugarcane, tropical fruits	Tropical climate, high multiple cropping index	Guangdong, Guangxi, Hainan
Southwest China	Rice, tea, forest economy	Mountainous and hilly, significant three-dimensional agriculture	Sichuan, Yunnan, Guizhou
Northwest China	Wheat, cotton, specialty agricultural products (such as wolfberry, grapes)	Dry and little rain, mainly irrigation agriculture	Xinjiang, Gansu, Ningxia
Qinghai-Tibet region	animal husbandry (yak, Tibetan sheep), highland barley	Alpine climate, fragile ecology	Tibet, Qinghai

Source: Organized by the author

In recent years, China's agricultural sector has achieved significant advancements in its development. China's production of agricultural products incremental continues to be at a high level, making it the world's top agricultural producer of wheat, rice and maize. In addition, China's production of rice, wheat, corn, soybeans, cotton, sugar and other agricultural products has also performed significantly, and these abundant agricultural products not only provide sufficient food and raw materials for the domestic market, but also offer significant support for the demand in the international market [246]. In recent years, China's participation in global agricultural trade has increased significantly, and it has gradually become an important player in the export markets represented by international agriculture [226]. Its export portfolio has undergone a national defense transformation, with a particular focus on the expansion of high value-added agricultural products, including fruits, vegetables, seafood and processed foods. Behind this growth is a combination of cyclical factors, technological advances, improved food safety standards, and optimized agricultural trade policies aimed at expanding market access. Together, these factors have boosted China's position in international agricultural trade and built a stronger export base.

The comprehensive production capacity of grain has improved significantly. in 2012, China's grain output exceeded 1.2 trillion kilograms for the first time, while it further increased to more than 1.3 trillion kilograms in 2015, and has remained above that level since then. According to statistics for 2023, the area under grain cultivation amounted to 171,624.47 thousand hectares, up 0.9 percent year-on-year, with total output reaching 695.41 million tons, up 1.3 percent from the previous year, and the total value of agricultural output reaching 870,733.8 billion yuan (Table 2.5).

Table 2.5

Total sown area of crops (thousands of hectares)

Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total sown area of crops	165183.32	166829.28	166939.04	166331.91	165902.38	165930.66	167487.14	168695.13	169990.92	171624.47
Sown area of grain crops	117455.18	118962.81	119230.06	117989.06	117038.21	116063.6	116768.17	117630.82	118332.11	118968.54
Sown area of cereals	101086.79	103225.31	102701.72	100764.56	99671.44	97847.03	97964.23	100176.66	99268.82	99926.36
Sown area of rice	30765.12	30784.09	30745.89	30747.19	30189.45	29693.52	30075.53	29921.15	29450.11	28949.06
Sown area of wheat	24442.7	24566.9	24665.78	24478.15	24266.19	23727.68	23379.99	23567.06	23518.46	23627.25
Sown area of corn	42996.81	44968.39	44177.61	42399	42130.05	41284.06	41264.26	43324.24	43070.15	44218.94
Sown area of beans	8823.92	8432.73	9287.21	10051.29	10186.34	11074.67	11593.45	10120.74	11877.93	11994.16
Sown area of soybeans	7097.57	6827.39	7598.53	8244.81	8412.77	9331.73	9882.5	8415.41	10243.74	10473.84
Sown area of potatoes	7544.47	7304.77	7241.14	7173.22	7180.43	7141.9	7210.49	7333.43	7185.35	7048.02
Sown area of oilseeds	13394.68	13314.39	13191.12	13223.16	12872.43	12925.43	13129.12	13102.24	13140.69	13922.2
Sown area of peanuts	4369.7	4385.52	4448.4	4607.66	4619.66	4633.48	4730.83	4805.29	4683.8	4797.84
Sown area of sugar crops	1737.1	1572.63	1555.25	1545.65	1622.94	1610.47	1568.48	1458.1	1453.48	1415.15
Sown area of vegetables	19224.12	19613.06	19553.14	19981.07	20438.94	20862.74	21485.48	21985.71	22434.06	22873.46

Source: systematized by the author

The output of grains (wheat, corn, beans, cotton, oilseeds, peanuts, and sugar) has steadily improved as can be seen in the statistical chart for 2014-2023 (Fig. 2.6). In terms of measures, an action plan to add 100 billion kilograms of new production capacity was implemented in 2023, improvement of corn and soybean was carried out, while the technology of banded composite planting was promoted. The yield of grain was raised to 5,845 kilograms per mu, an increase of 0.8 percent in comparison to the corresponding period.

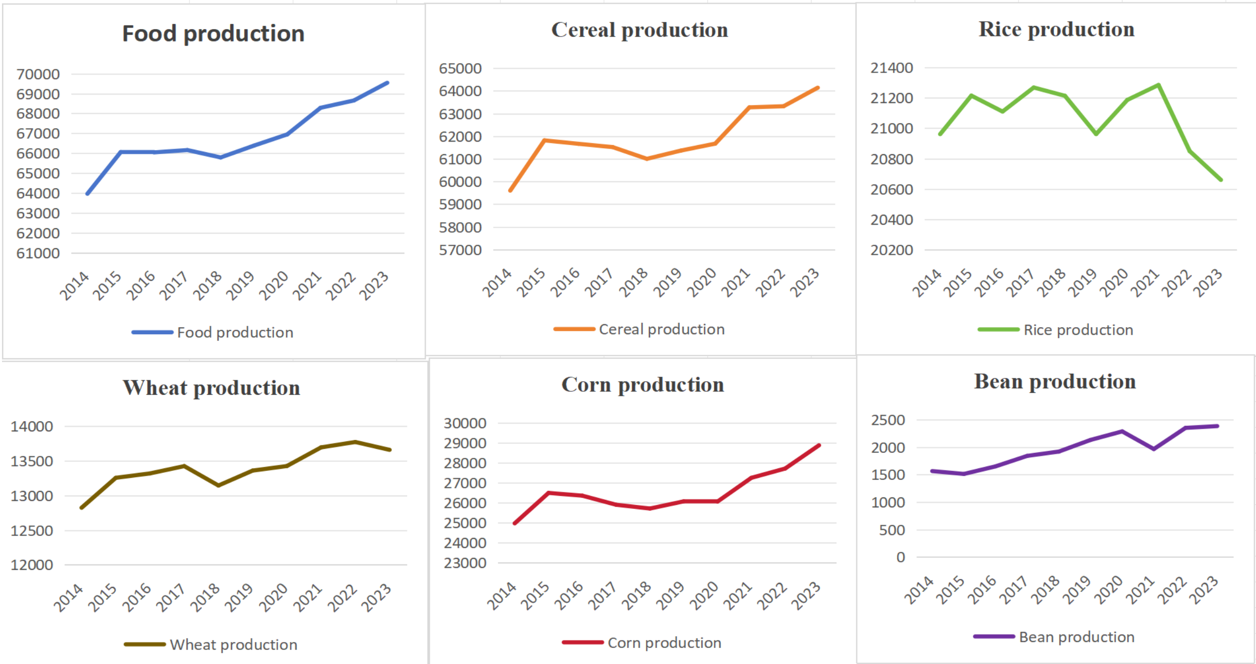


Fig. 2.6. food production of major crops (tons)

Source: systematized by the author

The growth of the forestry sector has exhibited a positive and robust trajectory, steadily according to the data in the statistical table (2014-2023) improving (Fig. 2.7). The Chinese government actively promotes green development, strengthens the transition from timber production to ecological restoration, sets specific forest ecosystem targets, and encourages foresters to expand their green space. In 2023, the total output value of the forestry sector and related industries amounted to 9.28 million, marking an increase of 2.3%. The number of visits in terms of ecotourism is reach 2,531 million, while the production of forest food will reach 226 million tons. In addition, between 2021 and 2023, the rehabilitation of 682,000 low-yield forests was implemented, further promoting the transformation and sustainable development of forestry.

In 2023, the production of pork, beef, sheep, and poultry meat reached a total of 96.41 million tons, reflecting an increase of 4.5% compared to the previous year (Fig. 2.8).

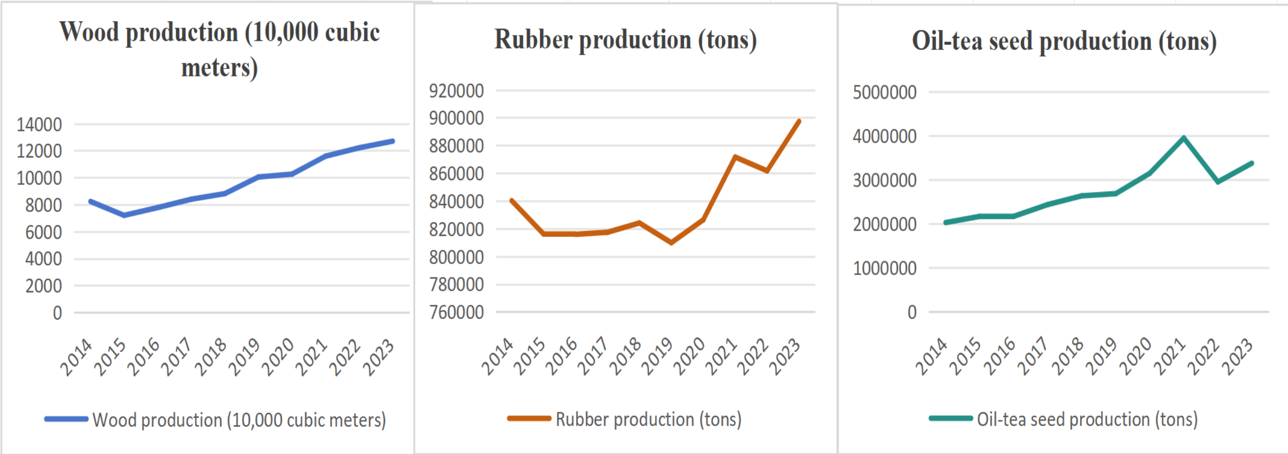


Fig. 2.7. Production of major forest products

Source: systematized by the author

Specifically, pork production amounted to 57.94 million tons, marking a rise of 4.6%; beef production was recorded at 7.53 million tons, with an increase of 4.8%; lamb production totaled 5.31 million tons, showing a growth of 1.3%; and poultry meat production reached 25.63 million tons, representing an increase of 4.9%. Additionally, milk production stood at 41.97 million tons, which is an increase of 6.7%, while poultry egg production was reported at 35.63 million tons – a rise of 3.1%. Annual pig farrowing was 726.62 million heads, up 3.8%; year-end pig inventory was 434.22 million heads, down 4.1% (National Bureau of Statistics of China)

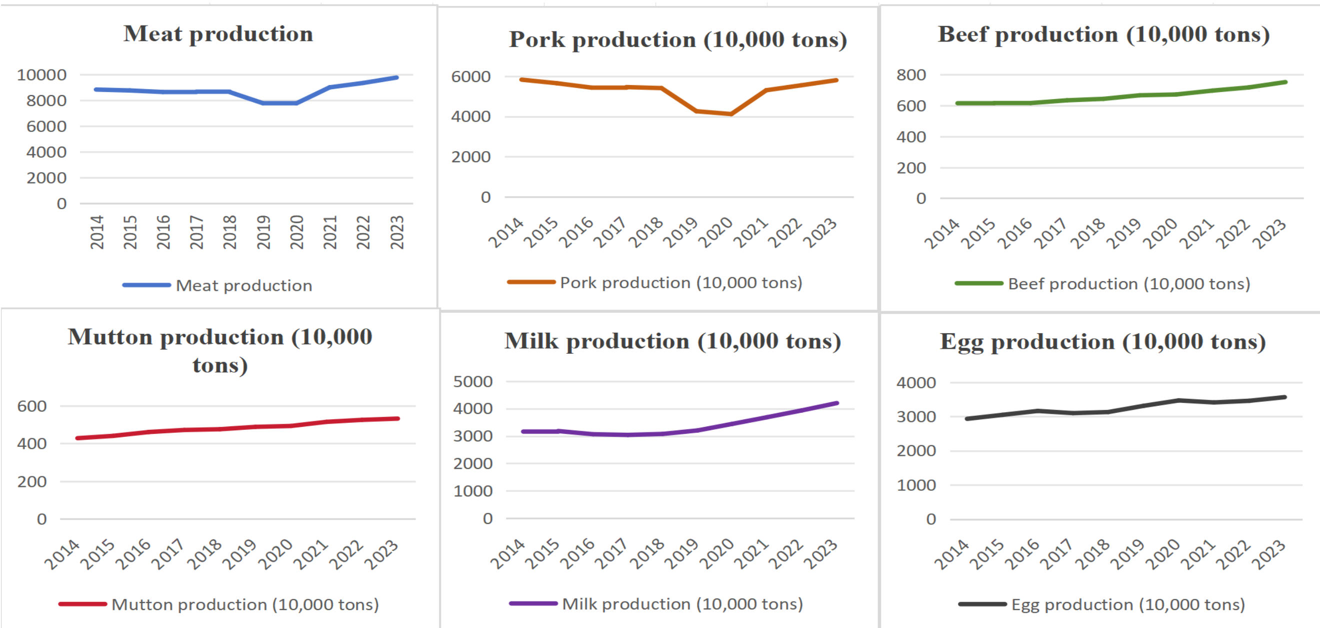


Fig. 2.8. Production of major livestock products

Source: systematized by the author

In terms of fishery, China's position in the global aquaculture sector needs to be strengthened as freshwater fish and marine aquaculture production rises (Fig. 2.9). In 2023, the total national output of aquaculture reached 71.1617 million tons, reflecting a year-on-year growth of 3.64%. Within this total, farmed aquatic products accounted for 58.0961 million tons, representing a 4.39% increase compared to the previous year, while capture fisheries yielded 13.0656 million tons, showing a modest rise of 0.47%. The proportion of aquaculture production to capture fisheries stood at 81.6% to 18.4%, respectively.

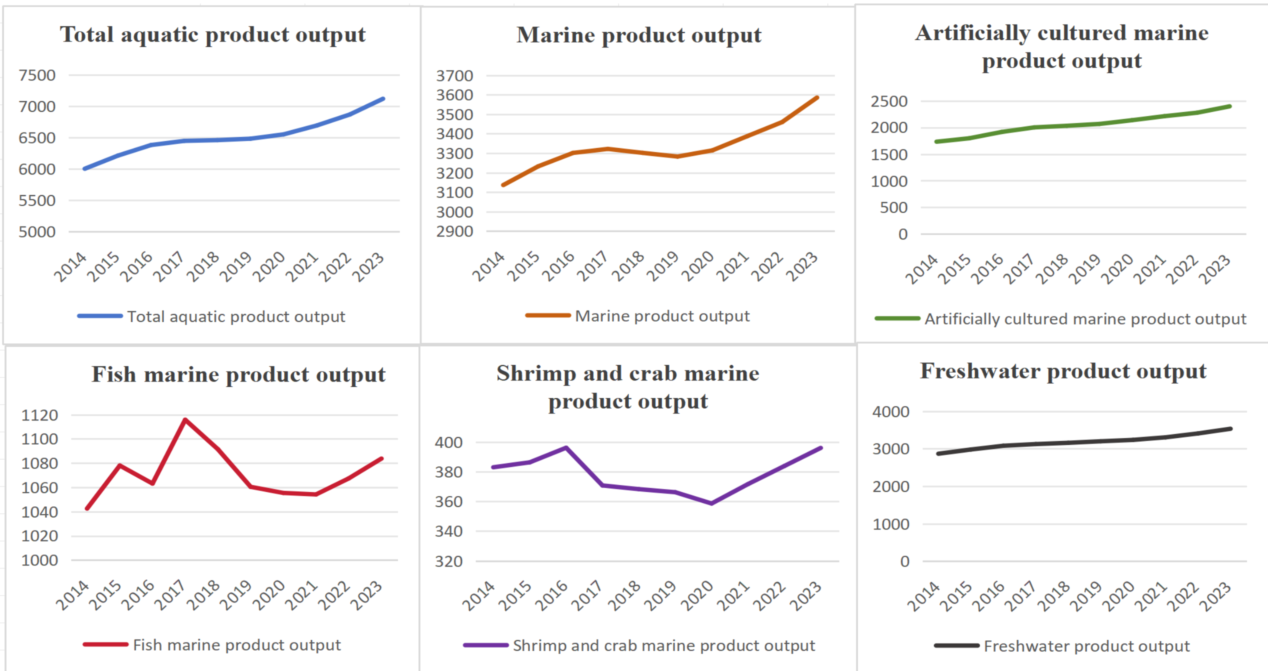


Fig. 2.9. Production of major fish products

Source: systematized by the author

Regarding water sources, the production of marine products amounted to 35.8532 million tons, indicating a 3.64% annual increase. In parallel, freshwater product output totaled 35.3855 million tons, up by 3.65% year-on-year. The distribution between marine and freshwater products was nearly balanced, with respective shares of 50.4% and 49.6%. In 2023, China's shrimp production amounted to 4.507 million tons, representing a 6.4% increase compared to the previous year. Among them, the output of South American white shrimp was 2,238,400 tons, an increase of 6.66% compared with 2022, placing it at the top globally. In 2023, China's shellfish farming production reached 16,659,000 tons, marking a year-on-year increase of 4.87%. Among them, the output of marine aquaculture shellfish is 16.466 million tons, up 4.87% year-on-year; the output of freshwater aquaculture shellfish is 198,400 tons, up 4.58% year-on-year (National Bureau of Statistics of China). The advancement of aquaculture technology, including the use of the Internet of Things and water quality surveillance, has improved production efficiency and product quality, while the promotion of new models such as deep-water net pens and sea farms continues to enhance the ability of sustainable development.

The cultivation of high-value crops has experienced notable advancement in recent years, particularly evident in the expanding production of key cash crops such as fruits, vegetables, tea, and coffee. Between 2018 and 2023, fruit production rose significantly from 256.875 million tons to 327.4428 million tons, corresponding to an average annual growth rate of 4.8%. Over the same period, vegetable output increased from 703.456 million tons to 828.681 million tons, with an annual average growth of 3.6%. Tea production followed a similar upward trajectory, growing from 2.6 million tons to 2.33395 million tons, yielding an average annual growth rate of 5.3%. Coffee production also expanded, rising from 1.2 million tons to 1.5 million tons and reflecting an annual average increase of 5.7%. In terms of export performance in 2023, China's fruit exports reached a total value of 4.98 billion USD, marking an 8% increase compared to the previous year. Vegetable exports stood at 18.54 billion USD, reflecting a year-on-year growth of 8.4%. In contrast, tea exports declined to 2.1 billion USD, representing a 16.5% decrease from the previous year; Nut exports also showed a continuing upward trend. Provinces such as Shandong, Fujian and Yunnan have become important production bases for meeting the fiercely growing demand for domestic consumption.

The structural optimization of industrial crop cultivation has continued to advance, with the accelerated development of high-quality, environmentally sustainable agricultural products emerging as a defining characteristic of the agricultural sector. By integrating modern agricultural practices and concepts, the sector has made significant strides in enhancing ecological sustainability, improving product quality, increasing specialization, and strengthening brand development. In

2023, China's total grain production reached 695.41 million tons, reflecting an increase of 8.88 million tons over the previous year, which corresponds to a year-on-year growth rate of 1.3% (Fig. 2.10). In terms of cash crops, total cotton output was 5.618 million tons, down 6.1 percent year-on-year. Oilseed crop production was 37.15 million tons internationalization of and sugar crop production was 114,500 tons. In the field of high-value crops, the output of fruits was 310,456,000 tons, the output of vegetables was 781,234,000 tons, and the output of tea was 32,000 tons.

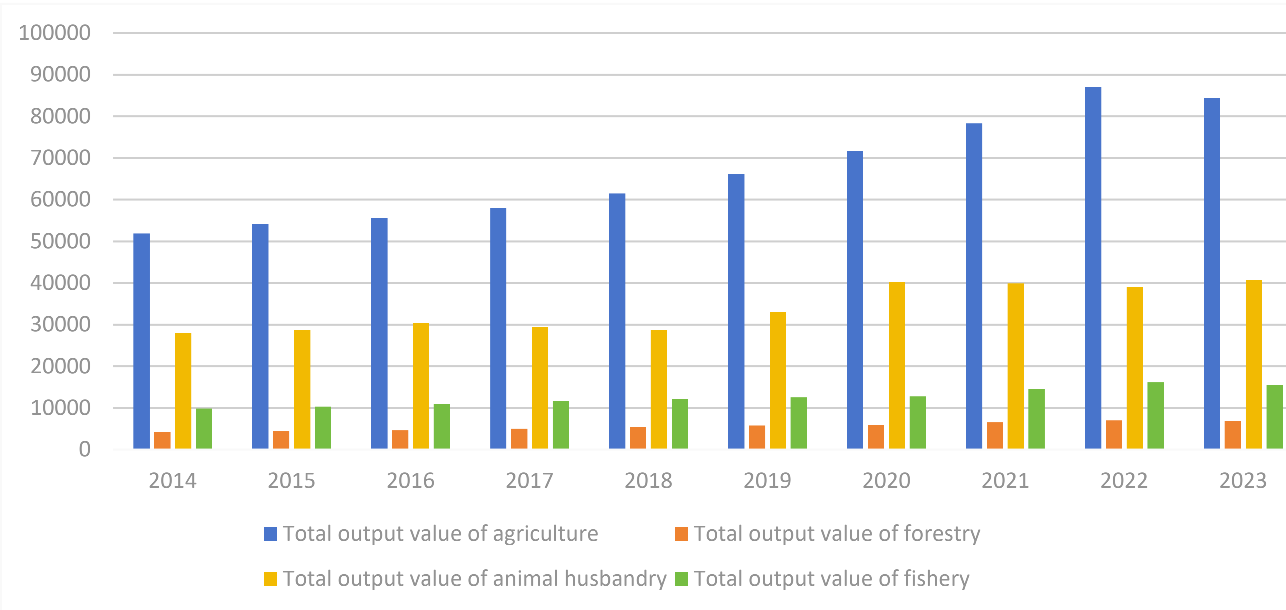


Fig. 2.10. Gross output value of agriculture, forestry, livestock and fisheries (billions of dollars)

Source: systematized by the author

The development of green and organic food sectors has accelerated significantly, with the number of certified green food products surpassing 50,000, while certified organic agricultural items have reached a total of 5 million. Through the continuous optimization of the planting structure, with the enhancement of agricultural product quality and the extensive application of agricultural science and technology, Chinese agriculture is rapidly advancing towards greener, more efficient, and sustainable development. Concurrently, the expansion of international market access and the deepening of trade relations have markedly enhanced the global standing of China's agricultural products.

An analysis of statistical data on the total output value of agriculture, forestry, animal husbandry, and fishery indicate a sustained and steady growth trajectory within China's agricultural sector. According to figures from 2023, the aggregate output value of these primary industries reached 15.85 trillion yuan, representing a year-on-year increase of 1.56%. Specifically, agriculture accounted for 54.93% of this total; animal husbandry contributed 24.58%; fisheries represented 10.16%; while forestry comprised 4.4% (National Bureau of Statistics of China). The industrial structure has undergone continuous optimization, thereby establishing a solid foundation for sustained and healthy advancement within the national economy. Concurrently, this advancement has offered strong support for the stable development of agricultural foreign trade.

2.2. PRC's Foreign Trade in Agriculture Segment: Role of Ukraine

People's Republic of China (PRC) is dedicated to achieving sustainable development and self-sufficiency in food production. This commitment is manifested in the consistent growth of agricultural output, the continuous optimization of agricultural structures, improvements in production efficiency, and enhanced policy support for investment in agriculture. Throughout the course of agricultural advancement, and in accordance with domestic demand and global trends in agricultural development, China is also making continuous transformation and changes to promote the better integration of Chinese agriculture into the internationalized world, and to maximize the promotion of sustainable global agricultural development and food security.

Key indicators of China's structural adjustment show that agriculture is gradually shifting from the early model of food production to high core value-added crops, animal husbandry transforming one of aquaculture. The output of fruits, vegetables, meat and aquaculture products continues to climb. By engaging in agricultural internationalization, China allocates agricultural resources globally, enhances the effective supply of agricultural goods, boosts farmers' income, drives domestic agricultural modernization, and significantly contributes to the global advancement of agriculture.

In the era of globalization, the progression of China's agricultural product foreign trade has exhibited a tendency towards diversification. The overall volume of agricultural imports has been progressively increasing on an annual basis, with a notable continuous rise in the quantity of imported agricultural goods. Based on the latest statistical information, the primary agricultural commodities imported by China include corn, meat, and dairy products.

In recent years, China's agricultural trade has undergone notable transformations, characterized by both dynamic changes and structural adjustments.With respect to exports, the value of China's agricultural product exports rose from 70.18 billion USD in 2015 to 98.93 billion USD in 2023, reflecting a general pattern of growth amid periodic fluctuations (Fig. 2.11).

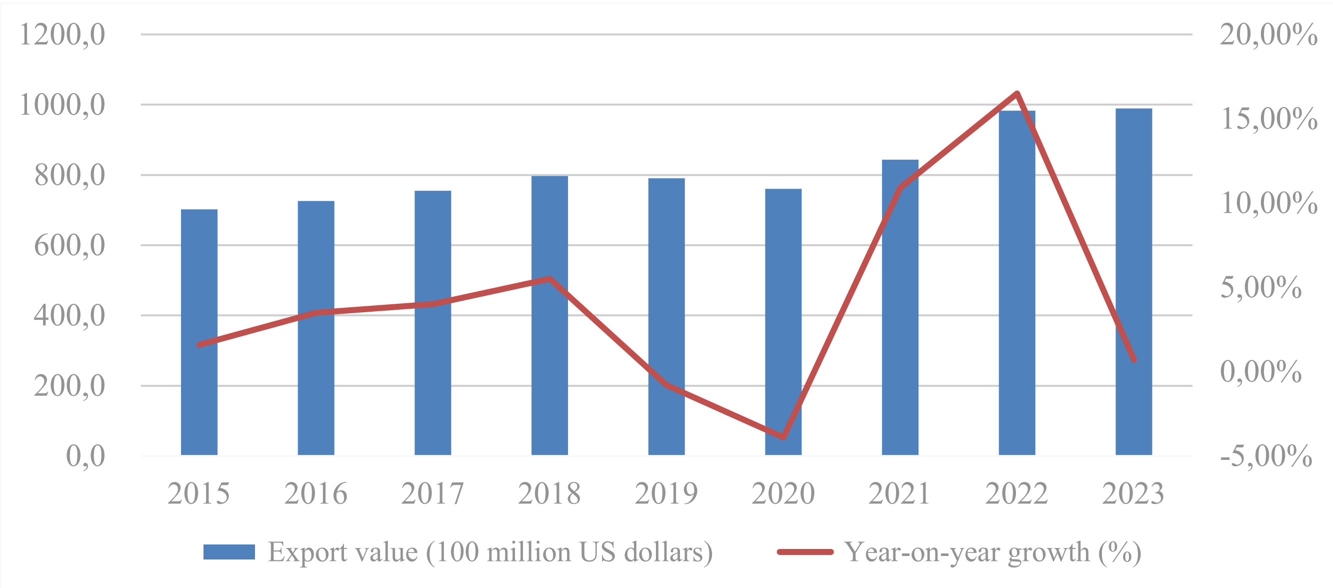


Fig. 2.11. China's agricultural product export value and year-on-year growth rate, 2015-2023

Source: systematized by the author

Although exports declined briefly in 2019 and 2020 due to the international trade environment and epidemics, they rebounded rapidly and hit new highs in 2021 and 2022, reaching US$84.35 billion and US$98.26 billion, with year-on-year growth rates of 10.9% and 16.5%, respectively. In 2023, exports declined slightly to US$98.93 billion, with year-on-year growth slowing to 0.7%, indicating a weakening of export growth momentum.

On the import side, China's agricultural imports grew substantially from 115.92 billion USD in 2015 to 234.11 billion USD in 2023, exhibiting a markedly higher average annual growth rate compared to export performance (Fig. 2.12, 2.13). In particular, in 2021, imports rose sharply to US$219.81 billion, up 28.7% year-on-year, driven mainly by growing domestic demand for commodities and high-protein food products. imports reached US$236.06 billion in 2022 and US$234.11 billion in 2023, with a slower growth rate, but generally remaining at a high level.

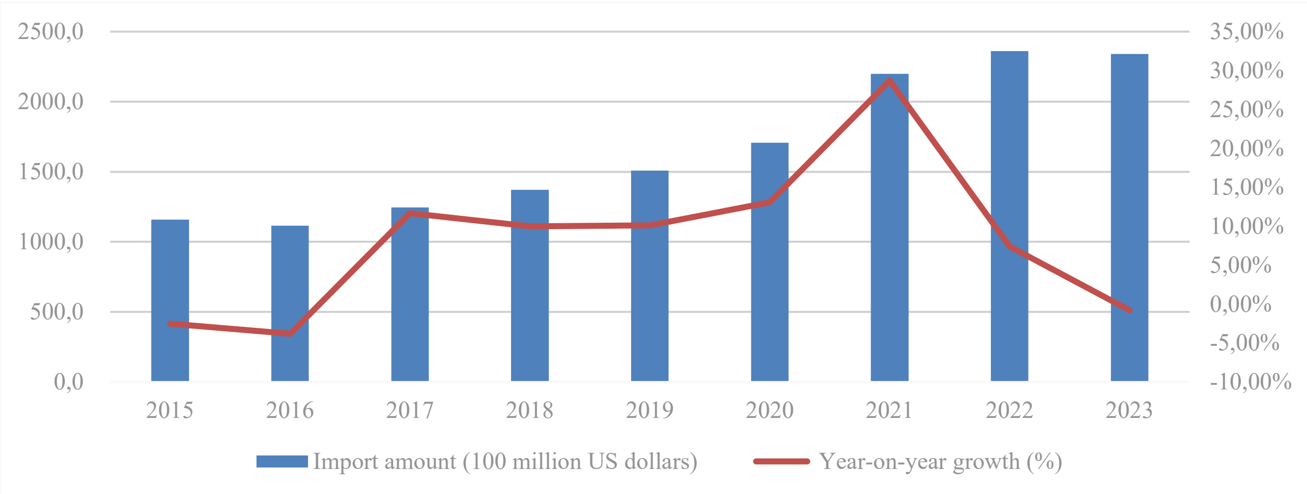


Fig. 2.12. China's agricultural product import value and year-on-year growth rate, 2015-2023

Source: systematized by the author

Regarding the agricultural trade balance, China's trade deficit expanded notably between 2015 and 2023, increasing from 45.74 billion USD to 135.18 billion USD. Over the same period, the deficit ratio rose from 39.5% to 57.7%. This widening gap is primarily attributed to the faster growth in agricultural imports relative to exports, driven in particular by sustained demand for bulk commodities such as soybeans and corn. Although the export portfolio has been gradually refined – evidenced by a marked rise in high value-added product exports – the resulting gains have not been sufficient to fully counterbalance the pressure imposed by the accelerating pace of import growth.

China's involvement in the internationalization of agriculture and its increasing agricultural imports are driven by a dual framework: the limitations imposed by resource endowments and the shifting dynamics of comparative advantage (Table 2.6).

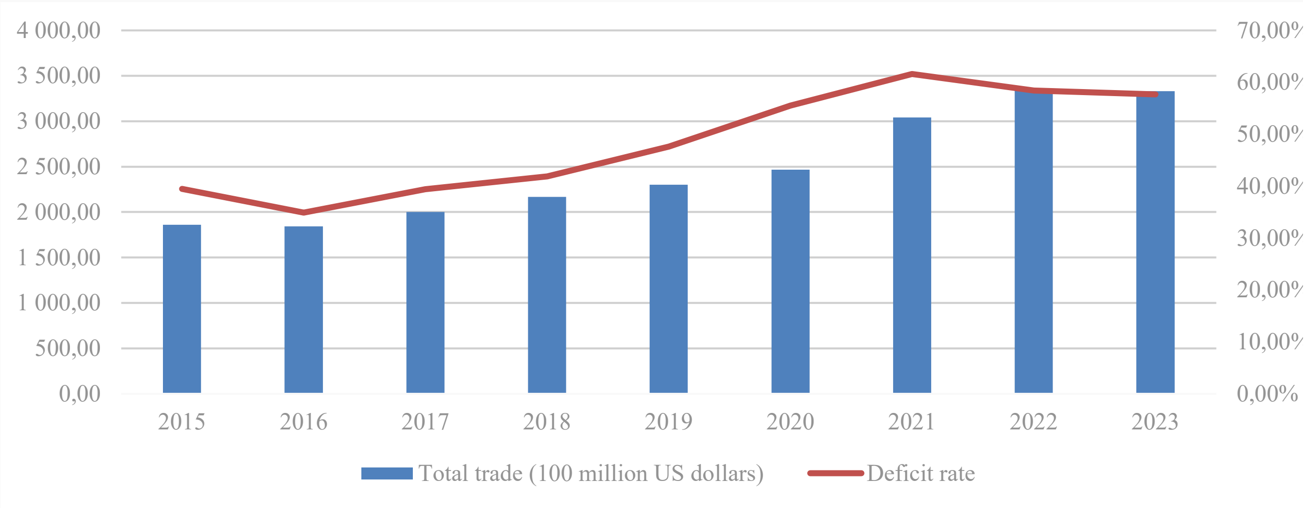


Fig. 2.13. China's agricultural trade volume and deficit ratio, 2015-2023

Source: systematized by the author

According to the Heckscher-Ohlin model, China's arable land resource endowment is insufficient (per capita arable land is 0.09 hectares, which is only 40% of the global average), and the efficiency of water resources is significantly lower than that of developed countries in agriculture (water consumption per unit of agricultural products exceeds the international advanced level by 30%). They need to realize resource reallocation through international trade. Reallocation [217]. Simultaneously, upgrading consumption structure triggered by the decline of Engel's coefficient， has given rise to the induced demand for high-protein feed crops and high-quality agricultural products, forming a gap between supply and demand under the "Baumol effect" [210].

On the supply side, the significant difference in total factor productivity (soybean yields are 42.7% lower than in the Americas) leads to high domestic opportunity costs, which is in line with the import substitution logic of Ricardo's theory of comparative advantage. From an institutional economics perspective, the tariff concession provisions of regional trade agreements such as RCEP (covering 8,000 tariff lines) reduce transaction costs, while the theory of supply chain resilience explains China's strategic choice to build a risk diversification mechanism by diversifying its import sources (soybean supplying countries increased to 35) [245]. This multidimensional interaction is essentially a combination of factor flows, technology diffusion and institutional synergy in the context of globalization, which is necessary to break through the resource and environmental carrying thresholds, achieve Pareto improvements and provide external momentum for the transformation of agricultural modernization.

Table 2.6

Motivations for China's Participation in the Internationalization of Agriculture and Expansion of Agricultural Imports

Rationale	Particular content	Theoretical foundation
Population growth and upgrading of dietary structure	China's large population and urbanization are driving a dietary transition (grains → meat/dairy), spurring a surge in demand for feed crops (soybeans/corn) and animal proteins	Demand-pull theory
Resource endowment constraints	The limited amount of arable land and water resources in China restricts its self-sufficiency in land-intensive crops like soybeans and corn.	Heckscher-Ohlin model
Productivity and cost	Soybean/corn etc. yields are 35%-50% below the international advanced level, and imports are more price-competitive	Theory of comparative advantage
Diversification needs	Consumption upgrade generates demand for high-end agricultural products (carmelon/avocado imports up 18% annually), filling category gaps	Consumer preference theory (CPT)
International market volatility and supply chain resilience	By diversifying its import sources, China can reduce its dependence on a single market and enhance the stability and security of its supply chain	Supply Chain Risk Management Theory
Policy support and trade cooperation	RCEP and other FTA tariff concessions cover 8,000 tariff lines, and policy guides enterprises to establish overseas direct sourcing channels	Theory of trade liberalization

Source: systematized by the author based on: [166]

Table 2.7 offers an in-depth analysis of China's imports of key agricultural commodities, emphasizing the main suppliers of these products. This examination highlights China's pivotal role in the global agricultural market and the ongoing diversification of its import sources. The primary exporters of soybeans to China are Brazil, the United States, and Argentina, all of which are major global producers. These imports are driven largely by the substantial demand for high-protein feed required by China's thriving livestock sector, particularly to support its extensive pork and poultry industries.

Table 2.7

China's major agricultural imports (2019-2023) (million tons)

Indicators	2019	2020	2021	2022	2023
Imports of cereals and cereal flour	1785.07	5908	6536	5319	5908
Imports of wheat	348.76	837.65	977	996	1210
Imports of paddy and rice	254.57	294.27	496	619	263
Imports of soybeans	8851.28	10031.45	9647	9053	9861
Imports of edible vegetable oils	953.28	982.76	1038	648	978
Imports of sugar	339.01	526.93	567	527	397
Imports of cotton	184.89	216	215	194	196

Source: Data adapted from China's General Administration of Customs

Soybeans, a core ingredient of feed, have become a key import commodity for China to cope with the growing domestic demand for meat. In terms of corn, China's main suppliers include the United States, Ukraine, Brazil, South Africa, and Myanmar. Corn is not only used for direct human consumption, but is also a key ingredient for animal feed in the livestock industry, and corn imports continue to climb as China's poultry and livestock industries continue to expand. This growing trend reflects China's high dependence on food security and feed supply, especially when domestic production cannot fully meet demand. For meat, Brazil, Argentina and the EU are the main suppliers to China. China's demand for meat, particularly pork, beef and poultry, has significantly exceeded domestic production in recent years. This dependence on meat imports has been further exacerbated by a sharp decline in domestic pork production. This phenomenon not only demonstrates China's structural shift in meat consumption, but also reflects its important role in the global meat supply chain. In the dairy industry, China's primary import origins are New Zealand and Australia. As China's urbanization progresses, demand for dairy products, especially high-quality milk and cheese, is growing rapidly, making China one of the world's largest importers of dairy products. New Zealand and Australia have long dominated the supply of the Chinese market with their high-quality dairy products. In addition, imports of wheat, which come mainly from Australia, France and Ukraine is both a major component of livestock feed and widely used in the brewing industry. Despite recent trade tensions between China and Australia, China has ensured by maintaining trade with these countries the stability of its wheat supply. This table emphasizes China's dependence on international markets for key agricultural commodities, especially staples such as soybeans, corn, and meat that are vital to its population and livestock. The wide range of suppliers from regions such as the Americas, Europe, and Oceania highlights China's strategic initiatives to secure its food supply and reduce the risks associated with trade disputes.

China's approach to securing agricultural imports relies on a strong and diversified global supply chain. With growing concerns about food security and increasing reliance on foreign suppliers, China has strategically diversified its import sources to avoid overdependence on any one country or region [1]. China chose countries with relatively proactive policies and supply chains conducive to promoting agricultural imports as its main supply regions.

Table 2.8 highlights the geographic diversity of China's agricultural import partners, helping to ensure food security and reduce trade risks. By sourcing from different regions, China can mitigate the impact of trade conflicts or disruptions in any single market.

Table 2.8

Main supplying regions of China for imported agricultural products (2023)

Area	Main imports	Strategic Importance
South America	Soybeans, meat, corn	Diversity from the United States
North America	Soybeans, corn, pork	Reliable large supplier
Australia	Wheat, beef, dairy products	Close trade relations
New Zealand	Milk	Supplier of high-quality dairy products
Africa	Cotton, palm oil	Emerging Partners

Source: Department of Commerce data, 2023

Brazil and Argentina, in particular, have become important suppliers of soybeans and meat to China. Brazil alone accounts for more than 60% of China's soybean imports. The Chinese government and private companies have invested heavily in South American agriculture, including developing logistics and infrastructure to ensure a steady flow of agricultural products. Close trade relations between China and South America have proved crucial, especially as China seeks to reduce its dependence on U.S. agricultural exports [119].

The United States remains a major supplier of agricultural products to China, particularly soybeans, corn and pork. Despite trade conflicts in recent years, China has resumed importing large quantities of U.S. soybeans following the signing of the first phase of a trade agreement in 2020. U.S. agricultural exports to China rebounded to $26.4 billion in 2021, driven largely by soybean and corn sales. However, ongoing trade tensions and the risk of future tariffs have led China to diversify its suppliers, particularly of key commodities such as soybeans and grains [144].

China has also developed strong trade relations with Australia and New Zealand, particularly in dairy, beef and wheat imports [237]. New Zealand meets much of China's dairy demand, while Australia has historically been a major source of and beef wheat. However, diplomatic tensions between China and Australia have led to Australian in recent years increased tariffs on, pushing China to look to alternative suppliers such as France and Ukraine wheat. Despite these challenges, trade with New Zealand remains strong, particularly in the dairy sector.

The growing Chinese investment in Africa, especially via the Belt and Road Initiative (BRI), has enhanced China's agricultural connections with the continent. Although Africa is not yet a major source of Chinese agricultural imports, the relationship is growing [234]. China has made significant investments in African agriculture, particularly in infrastructure, with an eye to securing future supplies of cotton, palm oil and tropical fruits.

In the era of globalization, China's agricultural exports are primarily characterized by products that are labor-intensive and have high value-added components, with rice, vegetables, fruits and aquatic products constituting the core export categories. This export pattern fully reflects China's comparative advantages in agricultural production efficiency and industry chain integration, especially vegetable and fruit exports have always ranked among the top in the world [249]. In terms of regional distribution, the export market shows obvious diversified characteristics, mainly concentrated in economically developed or densely populated regions such as Southeast Asia, Japan and the European Union. Southeast Asia is the main destination for Chinese rice and vegetables due to its geographical proximity and similarity in food culture, while Japan and the EU are important export markets for Chinese fruits and aquatic products due to their demand for high-quality agricultural products [94]. However, with the intensification of competition in the international market and the increase of trade barriers, China's agricultural exports are facing the dual challenges of quality upgrading and branding. Therefore, promoting the optimization of export product structure and enhancing international competitiveness have become the core issues of China's agricultural globalization strategy.

China's involvement in the internationalization of agriculture and its efforts to increase agricultural exports can be understood through a multidimensional theoretical perspective (Table 2.9). According to the theory of comparative advantage, China possesses considerable factor endowment benefits in the production of labor-intensive agricultural goods, and the reallocation of resources through specialized production and international trade is in line with the welfare-enhancing logic of the Ricardo model [91]. Demand-pull theory shows that export expansion raises the elasticity coefficient of rural employment through the multiplier effect (empirical research shows that for every 1% increase in the value of agricultural exports, rural employment grows by 0.3%), and effectively alleviates the urban-rural income gap (Gini coefficient decreases by 0.15). Under the innovation-driven perspective, quality regulations in export markets force the reconstruction of the agricultural production function, such as the HACCP certification coverage rate increased from 12% in 2010 to 68% in 2023, fostering an average annual growth rate of total factor productivity at 2.7%.

Table 2.9

Motivations for China's Participation in the Internationalization of Agriculture and Expansion of Agricultural Exports

Rationale	Particular content	Theoretical foundation
Utilizing Comparative Advantages	China holds a comparative advantage in the production of labor-intensive agricultural products, including seafood, vegetables, and fruits. By exporting these goods, China can acquire land-intensive agricultural products, thereby enhancing its overall welfare.	Theory of comparative advantage
Increasing farmers' incomes	Expanding agricultural exports can create more jobs and increase incomes for farmers and promote rural economic development	Demand-pull theory
Promoting modernization of agriculture	Export demand drives the technological advancement and standardization of agricultural production, while also supporting the transition towards agricultural modernization.	Innovation drive theory
Enhancing international impact	To enhance China's influence and presence in the global agricultural sector, it is essential to promote the export of high-quality, safe, and diverse agricultural products.	International Competitiveness Theory
Meeting the needs of the global market	The global market is experiencing an increasing demand for agricultural products, and China's agricultural exports can meet this demand while gaining a larger market share.	Market demand theory
Policy support and trade cooperation	Tariff concessions under FTAs such as RCEP cover 8,000 tariff lines, and policies guide enterprises to set up overseas direct sourcing channels to promote agricultural exports	Theory of trade liberalization

Source: Organized by the author based on: [2]

In the framework of international competitiveness theory, agricultural exports, as a non-price competition carrier, enhance national soft power through brand premium, which is in line with the Porter's Diamond Model's path of competitive advantage construction. The theory of global value chain further reveals that China has embedded itself in the regional production network through the 8,000 tariff concessions under the RCEP framework, increasing its share of intermediate exports in the ASEAN market from 18% in 2015 to 34% in 2023, and realizing a paradigm shift from "quantitative expansion" to "quality dominance". This strategic choice is essentially a Pareto-improvement process of factor flows, institutional synergy and technology diffusion in the context of globalization, and its necessity is rooted in the demand for modernization and transformation to break through domestic resource constraints and achieve increasing marginal returns in agriculture.

In the past six years, China's key agricultural products have undergone substantial shifts and developments in both production and exports (Table 2.10). Specifically, the production of vegetables and grains has remained at a high level, production stability, fruit production is noteworthy, and sugar production has declined after a period of stabilization, which may be closely related to the continued market demand and the adjustment of planting structure [139].

Table 2.10

The quantity and value of China's exports of key agricultural products over the past six years

Indicators	2018	2019	2020	2021	2022	2023
1	2	3	4	5	6	7
Rice and paddy export quantity (10,000 tons)	208.93	274.76	230.43	242	219	160
Rice and paddy export value (million US dollars)	887.5	1059.03	916.37	940.7	945.67	889.27
Corn export quantity (10,000 tons)	1.22	2.61	3.5	4	3.8	3.5
Corn export value (million US dollars)	5.99	9.87	12.5	14	13.5	12.8
Soybean export quantity (10,000 tons)	13	11.45	12	12.5	12	11.5
Soybean export value (million US dollars)	100.02	92.27	95	98	96.5	94
Aquatic product export quantity (10,000 tons)	425	418.55	374.74	375	370	370
Aquatic product export value (million US dollars)	22001.36	20326.57	18753.19	21584.76	22584.13	19871.52
Cotton export quantity (tons)	47349	52142.78	55,000	56000	54000	53000
Cotton export value (million US dollars)	93.65	89.58	95	97	96	94
Sugar export quantity (tons)	195747	185600.03	190000	195000	192000	190000
Sugar export value (million US dollars)	100.59	87.37	90	95	93	91

Source: systematized by the author

In 2023, both the volume and value of rice and paddy exports have experienced a decline, while corn exports remain relatively flat. Although the export volume of fishery products decreases, their export value peaks in 2021, indicating that the market is transitioning to higher value-added products. The export volume of cotton and sugar gradually recovers after being affected by global supply chain pressures and price volatility in 2020, reaching a peak in export value in 2021. The above changes not only reflect the flexibility and resilience shown by Chinese agriculture in adapting to changes in market demand and the international trade environment, but also its enhanced imports of high-value-added agricultural products Looking ahead, China's agricultural outlook is set to further consolidate its position in the international market through technological innovation and market confidence [79]. The year 2021 marked a pivotal turning point for China's agricultural exports. According to data, the total value of agricultural imports and exports reached an impressive $304.17 billion, reflecting a year-on-year increase of 23.2%. Exports alone totaled $84.35 billion, growing by 10.9% compared to the previous year. This upward trend highlights the increasing competitiveness and demand for China's agricultural products on the global market. Notably, the export value of aquatic products surged to $21.91 billion, a 15.1% year-on-year increase, indicating robust growth. Similarly, vegetable exports performed strongly, amounting to $15.77 billion, which represented a 5.6% increase over the previous year. These figures underscore the substantial expansion of China's agricultural exports in 2021.

The strength and diversity of China's agricultural export markets highlights key products distributed across different regions of the globe [84]. The high value of exports emphasizes China's importance as a supplier of food in the global economy. While China's agricultural exports are spread across the globe, certain regions are particularly receptive to Chinese goods. These key regions include Southeast Asia, the European Union, the United States and the Middle East, each of which presents unique opportunities and challenges for Chinese exporters. Southeast Asia in particular is an important market for Chinese agricultural products, especially fruits and vegetables. Geographic proximity, coupled with favorable trade agreements such as the ASEAN-China Free Trade Agreement (ACFTA), facilitates access to this rapidly expanding market. In 2021, China's agricultural exports to ASEAN countries reached approximately $12 billion, indicating strong demand for fresh produce and processed food. The EU is an important market for China's high value-added exports, including organic fruits and seafood. Despite strict food safety regulations in the EU, Chinese exporters have managed to enter this market by complying with international standards and improving product quality. in 2020, China's agricultural exports to the EU reached US$6.8 billion, mainly in seafood and processed food products. The United States is another important market for Chinese seafood, especially shrimp and tilapia, as well as processed foods. While trade tensions between the U.S. and China have affected agricultural trade flows, China has diversified its export markets to reduce the risks associated with tariffs and other trade barriers (Huang, 2021). Despite these challenges, exports to the United States totaled $4.5 billion in 2020. In addition, the Middle East has become an increasingly important market for Chinese agricultural exports, especially fruits, vegetables, and processed foods. Countries like Saudi Arabia, the UAE, and Qatar, which are heavily dependent on food imports due to their dry climate, create an opportunity that has been effectively seized by China. Agricultural exports to the Middle East reached US$5 billion in 2021 due to strong demand for fresh produce.

Table 2.11

Value of Agricultural Exports and Main Export Destinations, 2023

Type	Export value (100 million US dollars)	Main export destinations
Vegetable	139.69	Japan, South Korea, Southeast Asia
Fruit	70.82	Southeast Asia, Middle East, Europe
Aquatic products	1396.71	United States, Japan, European Union
Tea	122.3	Morocco, Central Asia, Russia

Source: systematized by the author

Based on data analysis, China has achieved substantial advancements in the fields of high-value crops and animal husbandry, aquaculture and agricultural exports between 2018 and 2023.Vegetable exports reached US$13.969 billion in 2023, while aquaculture exports stood at US$13.967 billion, mainly destined for Southeast Asia, Europe, and the United States. These figures demonstrate the growth and optimization of China’s agricultural industry chain, enhancing its competitiveness on the international stage [117].

China's agricultural foreign trade is important in several key aspects. First, it strengthens food security and ensures a stable supply of food against the backdrop of continued population growth. Secondly, it enhances the efficiency and quality of agricultural production by embracing modern technology and employing advanced methodologies. This progress not only contributes to the growth of rural incomes, but also to the economic development of these regions [103]. In addition, the promotion of sustainable farming techniques is essential for environmental protection and resource conservation. Increased agricultural capacity has also enhanced China's competitiveness in the global market, and technological innovation has driven better resource management and agriculture overall. Promoting the internationalization of agriculture is key for China to meet food security challenges, improve productivity and promote sustainable economic growth.

Overall, future trends in China's agricultural trade will be characterized by the: following a large trade deficit in agricultural products, with food and feed crops mainly imported to meet domestic demand. On the export side, high value-added products and technological innovation will be the main growth drivers, but the growth rate may stabilize; on the import side, demand for commodities and high-protein food will continue to drive import growth, but the growth rate may slow down due to the fluctuations in the international market and the recovery of domestic production capacity [9]. The trade deficit may continue to widen in the short term, but the trade balance is expected to gradually improve through optimizing the export structure, improving competitiveness and diversifying import sources. China's agricultural trade is expected to play an even more significant role in the global market, bringing about both increased challenges and novel opportunities.

China and Ukraine share a longstanding history of collaboration in agriculture, and China and Ukraine have achieved results in many fields such as agricultural trade, investment and technical exchanges. Ukraine ranks as one of the major agricultural producers in Europe, with fertile black soil and suitable climatic conditions. Its agricultural resources are rich, and its main agricultural products include wheat, corn, soybeans, sunflower seeds, sugar and so on. Ukraine's agricultural strengths are primarily attributed to its extensive arable land, the high quality of its agricultural products, and the cost-efficiency of its production processes.

Ukraine's agricultural exports, which are concentrated on grain and oilseed crops, are one of the world's leading grain exporters, and Ukraine's agricultural exports are of great importance to global food security. Ukraine's food exports are directed mainly to a number of countries and regions in Europe, Asia and Africa, providing these regions with a stable supply of food. In times of high volatility in the international food market, Ukrainian grain exports can effectively alleviate food shortages in some countries and play a positive role in maintaining the stability of the global food market.

Ukraine's agricultural trade has an important impact on Chinese agriculture. First of all, Ukraine, as a major global food producer, provides China with a stable supply of agricultural products, easing China's dependence in the food sector. Especially in grain crops such as corn and soybeans, Ukraine's imports have had a positive impact on price stability in the Chinese market. due to the relatively low production costs of Ukraine's agricultural products, Ukrainian products entering the Chinese market tend to reduce prices to a degree and promote the balance between demand and supply in the Chinese economy.

Table 2.12

Ukraine's agricultural product exports to China

Agricultural products	10,000 tons					US$ billion				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Corn	300	350	400	420	450	5.8	7.3	10.5	9.8	6.3
Soybeans	80	90	100	110	120	2.6	3.1	3.8	3.4	1.6
Sunflower oil	25	28	30	32	30	1.1	1.3	1.7	0.9	0.7
Wheat	50	60	70	75	80	0.8	1.1	1.3	0.5	0.2
Barley.	30	35	40	45	50	0.5	0.6	0.9	0.4	0.1

Source: systematized by the author

According to Table 2.12, Ukraine's exports of key agricultural products to China show a steady growth trend over the 2019-2023 period. The export volume and trade value of products such as corn, soybeans, sunflower oil, wheat and barley have increased. This is primarily attributed to the price competitiveness and superior quality of Ukraine's agricultural products, along with the strengthening trade collaboration between China and Ukraine.

China's huge market demand provides Ukrainian agriculture with new export channels and growth points. China's import demand promotes the expansion of Ukraine's agricultural production scale and drives the improvement of Ukraine's agricultural industry chain. Especially in the production of corn, soybeans and other crops, Ukrainian agriculture faces unprecedented export opportunities. However, China's demand for Ukrainian agriculture also poses some challenges. Ukraine's agricultural products are highly dependent on the Chinese market, and economic fluctuations or policy adjustments on either side may affect the stability of bilateral trade. In addition, there is still a gap between the productivity and technology level of Ukrainian agriculture and China's advanced agricultural technology. In recent years, Chinese and Ukrainian agriculture in terms of resource endowment, production advantages and market demand have seen complementarity with each other. Therefore, agricultural collaboration between the two sides extends beyond traditional trade transactions, for example, investment cooperation, technical cooperation, equipment investment, and more in-depth to the level of agricultural technology and sustainable development.

Trade cooperation: in the area of food trade, a series of trade agreements and memorandums of understanding between China and Ukraine have significantly increased the efficiency of agricultural trade, thereby reducing China's dependence on traditional suppliers such as the U.S. and Brazil. In 2021, the agricultural trade between China and Ukraine reached 4.7 billion U.S. dollars, accounting for over 70% of Ukraine's total exports to China. Key agricultural products exported from Ukraine to China include corn (30%), sunflower oil (20%), and barley (15%) [254]. In the field of trade in technology and equipment, China exports agricultural machinery, fertilizers, and agricultural technology and equipment to Ukraine. This initiative focuses on tackling technological weaknesses in the middle and lower segments of the agricultural value chain while enhancing the efficiency of agricultural production [252].

Investment cooperation: In terms of investment in agricultural infrastructure, Chinese enterprises have invested in Ukraine in the construction of agricultural infrastructure such as irrigation systems, storage facilities and processing plants. For example, COFCO has leased a large amount of land in the Amhara region of Ukraine to grow corn and wheat. By adopting advanced agricultural technology and management practices, the yields of corn and wheat have increased by 30% and 25%

respectively. COFCO invested 75 million US dollars to build a direct-cooled container terminal at Nikolaev Port in Ukraine, with a total throughput of 2.5 million tons per year and a storage capacity of 143,000 tons. In addition, COFCO has become the second largest vegetable oil exporter in Ukraine by acquiring all shares of Lai Bao Group in Ukraine, with an annual operating volume of 300,000 tons and a market share of 25%. In terms of investment in agricultural technology, Chinese companies are promoting advanced agricultural technologies in Ukraine, such as precision agriculture, drone technology and smart irrigation systems. Huawei has cooperated with Ukrainian companies to build smart farms, introducing Internet of Things and big data technologies to realize precise fertilization, smart irrigation and pest monitoring.

Technical cooperation: in the area of conservation tillage technology, China has widely implemented no-tillage seeding, straw incorporation into fields, and other soil-conserving cultivation techniques, helping Ukraine to reduce black soil erosion and increase the organic matter content of soil. For example, Heilongjiang Agricultural Reclamation Group cooperates with Ukrainian farms to carry out pilot conservation tillage projects, popularize no-tillage seeding, straw return to field and other technologies, which resulting in a 5-8 percent increase in soil organic matter and significantly decreasing soil erosion. Digital agriculture cooperation: the two sides have cooperated in the field of digital agriculture, utilizing technologies such as the Internet of Things, big data and artificial intelligence to improve agricultural production efficiency. For example, Huawei cooperated with Ukrainian agribusinesses to build smart farms, introducing IoT and big data technologies to achieve precise fertilizer application, smart irrigation, and pest and disease monitoring. Through these technologies, the farm's water utilization rate has increased by 30 percent, and yields have risen by 15 percent. [163], [236]

Cooperation in sustainable development: in the area of ecological agriculture, the two sides have cooperated in the development of biofuels from agricultural waste, converting corn stalks, sunflower seed husks and other waste into bioenergy, in line with the concept of the "stock-flow" cycle of ecological economics. For example, China and Ukraine have jointly built a biomass power plant with an annual processing capacity of 500,000 tons, which can reduce carbon emissions by 200,000 tons per year. In terms of carbon emission reduction cooperation, the two sides have promoted precision fertilization drone technology to reduce excessive fertilization and reduce greenhouse gas emissions while increasing crop yields. The two sides are also promoting the inclusion of agricultural cooperation projects in the international carbon trading system, creating both economic and ecological benefits for both sides [128].

As agricultural cooperation between China and Ukraine continues to grow, both nations are expected to enhance technical exchanges and collaboration within the agricultural industry chain. Given China's extensive experience in agricultural modernization and Ukraine's substantial agricultural production potential, there are significant opportunities for cooperation in areas such as smart agriculture, agricultural mechanization, and sustainable agriculture.

2.3. China's Role in International Capital Transfers in Agriculture

In recent years, as global economic integration has deepened, China has increasingly taken on a prominent role in the international movement of agricultural capital. This is particularly evident in two main areas: China's investments in overseas agriculture and its export of agricultural technology and cooperative initiatives.

China is actively expanding its overseas agricultural investment, promoting the transfer of agricultural capital through such strategies as outward foreign direct investment (FDI), land leasing and purchasing, mergers and acquisitions of overseas agricultural companies, resource optimization and strategic technological cooperation, and public-private partnership models (Table 2.14) [161]. In particular, driven by the Belt and Road Initiative, Chinese capital has been extensively utilized in the agricultural sector across Southeast Asia, Africa, Latin America, and other regions. This investment not only provides financial support for local agricultural production but also facilitates a more rational flow of global agricultural capital [208].

Table 2.14

Analyzing China's role in international agricultural capital transfers

Role	Concrete expression	Typical case	Data support (2023)	International impact
Outward foreign direct investment (ODI)	Investing in agricultural farming and processing initiatives in Africa, South America, and Southeast Asia to safeguard food security and resource supply.	COFCO builds 3 million tons soybean crushing base in Brazil	China's Agricultural ODI Stock Reaches $42 Billion, Growing at 15% Annually	Enhancement of agricultural production capacity in host countries (e.g., threefold increase in rice yields in Ethiopia)
Technology transfer	Export of hybrid rice, smart farm machinery, water-saving irrigation and other technologies	Longping Gaoke promotes hybrid rice technology to Africa, covering 600,000 hectares of farmland	Agricultural technology exports amounted to $3.5 billion and technical cooperation agreements covered 80 countries	Contribute to increased food self-sufficiency in developing countries (e.g., doubling of rice production in Madagascar)
Trade networking	Enhancing Agro-Logistics and Trade Corridors through the Belt and Road Initiative	China-European liner cold chain line to transport European carrots, Southeast Asian durian, time efficiency increased by 60 percent	China-Europe shuttle train transports 230,000 tons of agricultural products annually, reducing costs by 40 percent	Reshaping Global Agricultural Trade Flows (Central Asian Wheat Transit to Southeast Asia via China)
Financial support	Financing agricultural infrastructure through multilateral financial institutions	ADB Loan Supports Upgrading of Pakistan's Agricultural Irrigation System	ADB approves $12 billion in cumulative loans for agricultural projects	Improvement of agricultural infrastructure in developing countries (e.g., irrigation coverage of farmland increased to 45% in Laos)
Standards and Rulemaking	Taking the lead in formulating international agricultural technology standards and promoting cross-border mutual recognition of quality certification	Leading the development of the International Standard for Blockchain Traceability of Cross-Border Agricultural Products	Participation in the formulation of 38 international agricultural standards, along with blockchain traceability initiatives spanning 100 countries.	Enhancing China's influence in global agricultural governance (e.g., RCEP tariff regulations for agricultural products)
Sustainable development initiatives	Promoting investment in green agriculture and the application of climate-smart agricultural technologies	Construction of Solar Irrigation Demonstration Project in Kenya	30% of China's outbound agricultural investment is allocated to green projects, and the exports of emissions reduction technologies have risen by 25%.	Contribute to global emissions reductions in agriculture (e.g., 18% reduction in the carbon footprint of African agriculture)

Source: organized by the author based on: [75]

The significance of foreign direct investment (FDI) in the agricultural sector is undeniable, particularly within the framework of globalization, as it promotes the modernization and sustainable development of agriculture in host countries through financial support, technology transfer, and market integration. FDI not only improves the efficiency of agricultural production and promotes the construction of infrastructure, but also leads to the marketization of agricultural products, and improves rural employment and livelihoods. However, FDI also faces a number of challenges, such as competition for land resources, environmental sustainability issues, and declining agricultural autonomy, which may lead to conflicts between local communities and foreign-funded enterprises or negatively affect the ecosystem [113]. Therefore, countries need to formulate reasonable policies when attracting agricultural FDI to ensure its comprehensive social, economic and environmental benefits. China's agricultural investments in areas such as Africa, Southeast Asia, and Latin America. For instance, a "win-win" model has been effectively demonstrated, promoting local agricultural modernization through technical assistance and market support [152]. However, the success of agricultural FDI depends not only on financial inputs, but also on coordination with East Asian countries' development plans to ensure tariffs and benefit sharing. In the future, as global food demand increases, agricultural Foreign Direct Investment (FDI) will remain crucial for ensuring food security and advancing sustainable agricultural development.

It should be marked that there is a notable disparity between the official figures on FDI provided by Ministry of Commerce and by the China Global Investment Tracker (Figure 2.14).

The Fig. 2.15 illustrates the trend of China's outward agricultural investment over time. Generally, it indicates a pattern of growth followed by fluctuations in China's external investments from 2005 to 2016, the data show a continuous upward trend, especially in 2016 reached the peak. 2017, after the two data began to rise as well as the data of the Ministry of Commerce showed a large decline, the restriction of irrational investment, and the mode of outward investment gradually changed from "expanding" to "expanding".

Since 2017, the government strengthened the supervision of outward investment, especially China was affected by the intensification of global geopolitical and trade difficulties, the rise in investment risks, and the tightening of the Chinese government's outbound investment policy. As a result, the Chinese government has strengthened the regulation of outbound investment, especially the restriction of irrational investment, and the mode of outbound investment has gradually shifted from the "expanding experience type" to the "rational layout type" [27].

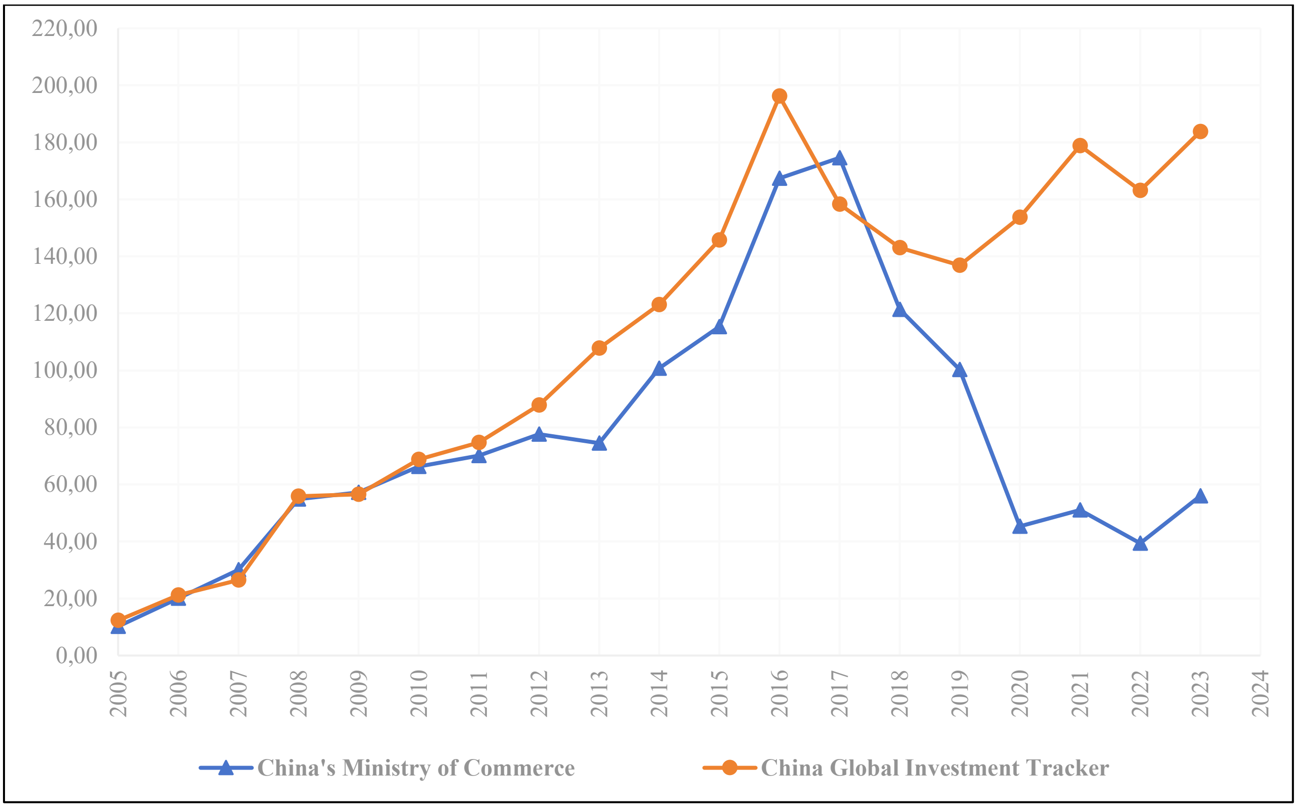


Fig. 2.14. Comparison of China's Outbound Investment (Billions of US dollars)

Source: [70]

Table 2.15 unpacks China's investment in agriculture across multiple geographic regions to ensure domestic food supply, access to agricultural demand, and robust global supply chains. Chinese agricultural investment in Africa has seen a substantial increase as an integral component of the BRI. China has invested in land, agricultural infrastructure, and agribusinesses in a number of African countries, such as Kazakhstan, Mozambique, and Zambia [64]. These investments are aimed at boosting local agricultural production in Africa and securing China's food exports, particularly in key agricultural products such as maize, soybeans, and rice. Demonstration projects include in the first large-scale agricultural start-ups for the production of sesame and wheat, which are then exported to China or other markets [5].

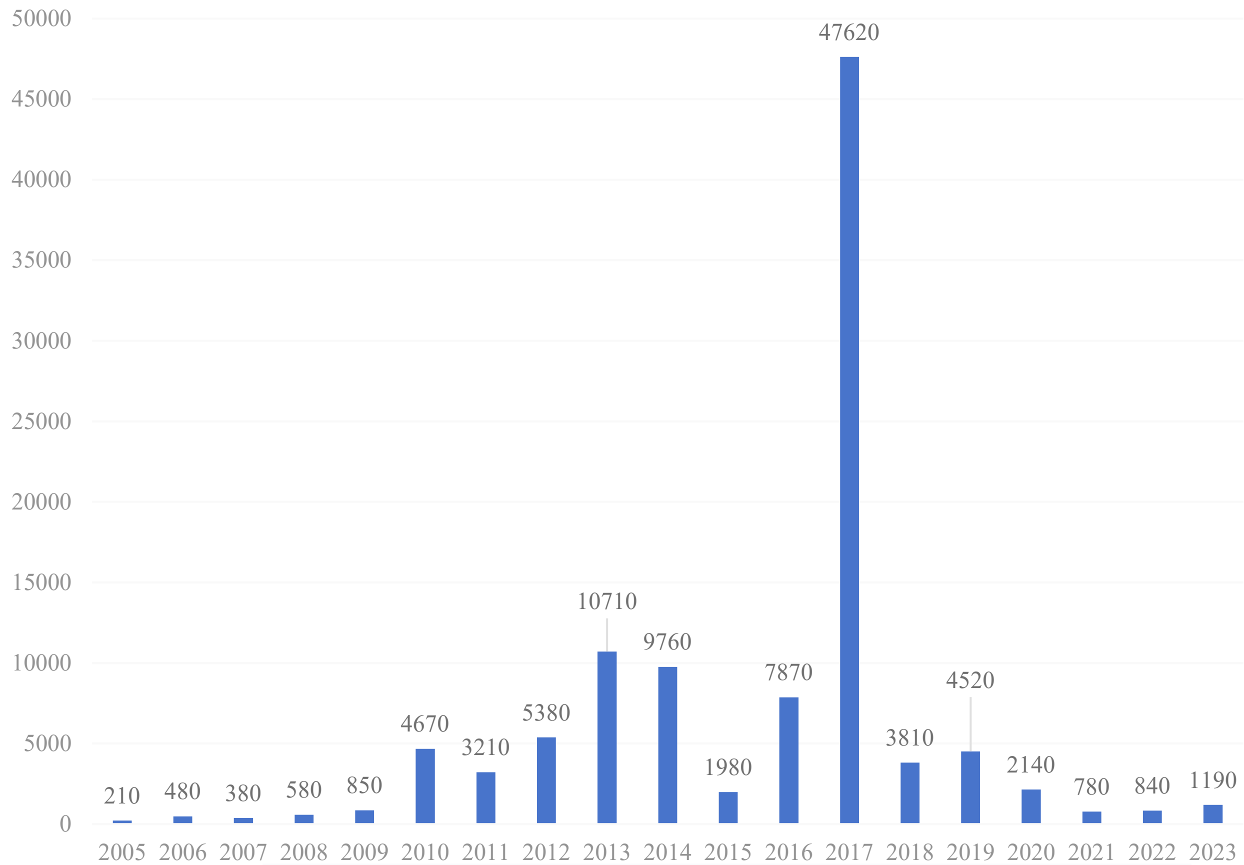


Fig. 2.15. China's overseas agricultural investment and construction scale from 2005 to 2023 (in billion US dollars)

Source: Ministry of Commerce data, 2021

Table 2.15

Main Investment Regions for Agricultural FDI in China (2021)

area	Main investment focus	Investment value (billion USD)	Key countries
Africa	Land acquisition, agricultural infrastructure	5.2	Ethiopia, Mozambique, Zambia
Southeast Asia	Rubber, palm oil, aquaculture	3.8	Laos, Cambodia, Myanmar
Latin America	Soy, beef, agribusiness partnership	9.5	Brazil, Argentina, Uruguay

Source: Data adapted from Ministry of Commerce, 2021

Southeast Asia is another major region of focus for Chinese FDI in agriculture. China has invested heavily in agricultural projects in Laos, Cambodia, and Kampuchea, focusing mainly on rubber plantations, palm oil farms, and aquaculture. In addition, Chinese companies have participated in the construction and modernization of agricultural infrastructure in these countries, including irrigation systems, cold storage, and transport logistics. This is not only in the interest of Chinese investors in equipment, but also benefits the agricultural development of the host countries [83].

An important target for Chinese agricultural outward FDI, especially in Brazil and Argentina, which are important suppliers of Chinese soybeans and beef. China's main investments in Latin America are focused on acquiring large amounts of agricultural land, while modernizing agricultural production is considered through cooperation with technology and agribusiness. These investments are related to the stabilization and maintenance of a stable supply of key agricultural commodities, especially to the importance of soybeans for China's urgently growing livestock sector [62].

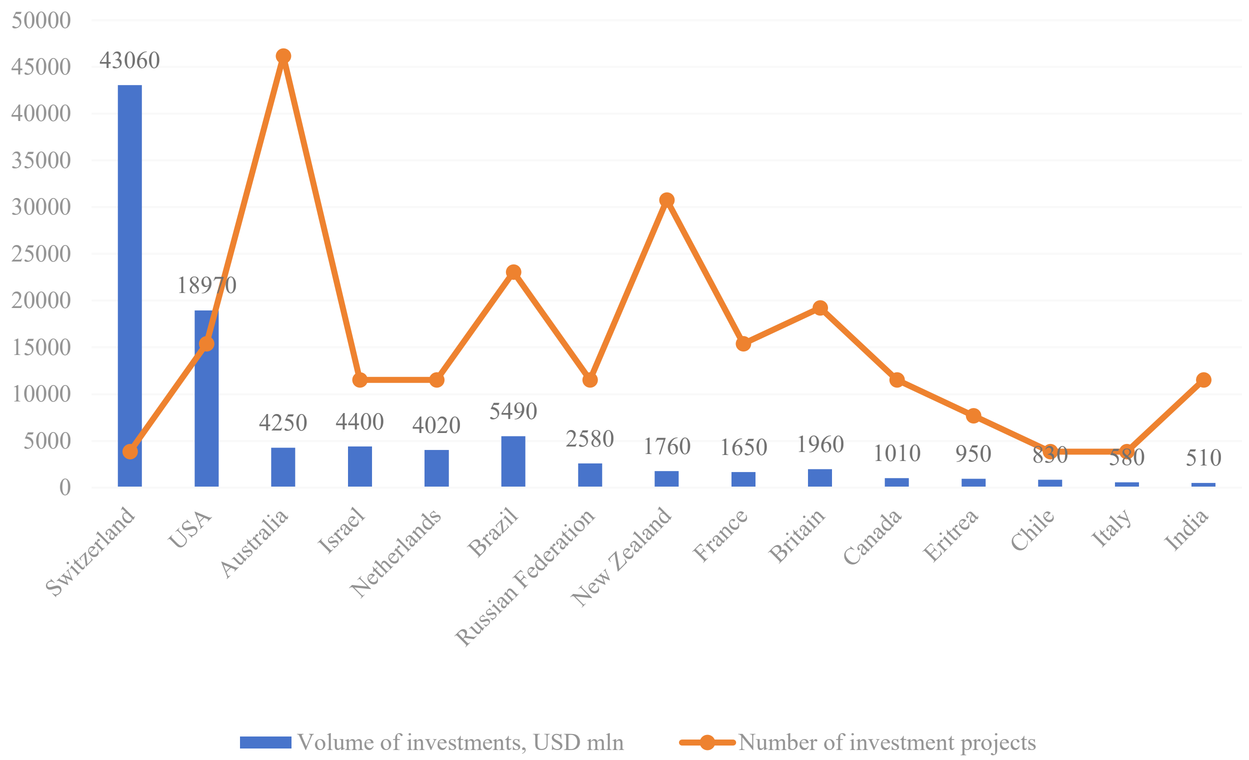


Fig. 2.16. The primary recipients of China's outward agricultural FDIs, 2005-2023

Source: Data adapted from Ministry of Commerce

From 2005 to 2023, the distribution of major recipients of China's outward agricultural direct investment (FDI) shows significant dynamic changes. Chinese agricultural investment in Africa has experienced a significant rise, serving as a crucial element of the BRI, with relatively small but rapidly growing investment. In the middle phase (2011-2016), the scope of investment expanded to cover more developing countries, especially emerging markets in Africa and South America, and the scale of investment rose amidst fluctuations, reflecting China's strategy of seeking agricultural resources and markets on a global scale. In the late stage (2017-2023), the investment is more diversified, including not only traditional big agricultural countries, but also involving some countries with special agricultural resources or geographic location advantages, and the scale of investment tends to be stable or slightly fluctuating, which may be related to the global economic situation, geopolitical factors, and China's domestic policy adjustments [195]. The expansion and shifts in the distribution of China's outward agricultural foreign direct investment (FDI) highlight the country’s increasing influence in the global agricultural sector and the development of its strategic positioning.

Overall, these investment practices have fully demonstrated the positive role of China's agricultural OFDI in resource integration, technology introduction domestic industrial upgrading, and provided important Chinese wisdom and power for global agricultural cooperation and development. The internationalization strategy of Chinese enterprises not only offers a robust development pathway for agriculture but also contributes significantly to fostering the sustainable progression of agricultural practices worldwide.

China is actively engaged in the global agricultural production landscape through the acquisition or leasing of land overseas, mainly in Africa, Southeast Asia, South America, and resource-rich regions (Table 2.17) [202]. These investments on food crops, aiming to compensate for domestic resource constraints and secure the food supply chain, wheat) and cash crops.

Studies have shown that such investments have enhanced the agricultural production capacity of host countries, with Chinese companies investing in irrigation systems and agricultural infrastructure, improving local agricultural production conditions; Chinese agricultural experts have provided training to local farmers and introduced and promoted modern planting techniques, increasing the productivity of local agriculture. However, challenges such as land tenure disputes, environmental sustainability issues and socio-cultural conflicts pose potential risks to the long-term stability of investments [106].

Table 2.16

Major Investors in China's Agricultural OFDI, 2005-2023

Investor	**Volume, millions of dollars**	**Number of projects**	**Investor**	**Volume, millions of dollars**	**Number of projects**
China National Chemical Corporation	50170	10	National Construction Project	1020	4
WH Group (formerly Shuanghui)	7580	3	Yili Industry	1020	4
China National Cereals, Oils and Foodstuffs Corporation	6360	10	Sichuan Railway Investment	950	1
China National Machinery Industry Corporation (SINOMACH)	5370	22	China Railway Construction	770	2
Bright Food	4210	5	China Poly	730	3
China International Trust and Investment Corporation (CITIC)	3020	7	Shanghai Zhongfu	730	1
Myth; legend	2480	3	Shanghai Pengxin	710	3
China Investment Corporation	2410	2	Wangxi Group, Primavera Capital	580	1
National Development and Investment Corporation	2130	5	Chongqing Food	570	1
China Communications Construction	1700	8	Chinese Resources	540	1
China North Industries Corporation	1500	1	Alibaba	510	3
Power Construction Corporation of China (China Power)	1080	3	China Railway Engineering	500	2

Source: Data adapted from Ministry of Commerce

In the future, China needs to further optimize its investment model and strengthen the benefit-sharing mechanism with host countries. The internationalization strategy of Chinese enterprises not only provides a strong developmental pathway for agriculture but also significantly contributes to the sustainable advancement of global agricultural practices. Through China M&As with overseas agricultural companies, has achieved global integration of technology, management experience and market channels, significantly enhancing its international competitiveness. In the case of COFCO, for example, its acquisition of Nidera in the Netherlands and Noble Agri in Singapore not only provided it with advanced agricultural technologies and management models, but also successfully expanded its global food supply chain network and strengthened its bargaining power in the international market [235]. Studies have shown that such M&A behaviors have helped Chinese firms rapidly integrate into the global agricultural value chain, while promoting cross-border transfer and application of agricultural technologies. However, cultural integration, regulatory compliance and financial risks during the M&A process are still the main challenges faced by enterprises. In the future, Chinese agribusinesses need to further optimize their M&A strategies and strengthen their risk management and control capabilities.

Table 2.17

Land Leasing and Purchasing Strategies for (as of 2023) Agricultural Investment in China

Country of investment	Investment Areas	Total investment (billions of dollars)	Leased land area (million hectares)
Ethiopia	Maize, wheat	2.5	10
Tanzania	maize	1.8	8
Cambodian	maize	3	15
Laos	caoutchouc	2.2	10
Brazilian	Soybeans, corn	5	20
Belarus	Maize, wheat	26	300
Argentina	Soybeans, wheat	4	15
Pakistan	Rice, wheat	2.8	12
Mozambique	Rice, maize	1.5	12
Indonesia	Rubber and palm oil	4.2	18

Source: Data adapted from Ministry of Commerce

Over the course of the past decade, China has made a series of key acquisitions in the global agricultural sector aimed at boosting domestic agricultural productivity and enhancing its competitiveness in the global market by acquiring important agricultural technologies, production capacity and supply chain management resources. These strategic acquisitions have focused on multinational agribusinesses, particularly those with leading agricultural technologies and broad market coverage [224]. Through these acquisitions, Chinese firms have not only gained access to advanced agricultural technologies and products, but have also effectively expanded their influence.

The acquisition of by China National Chemical Corporation (ChemChina) in 2017 agribusiness Syngenta was a landmark event in the global agriculture industry (Table 2.18). Syngenta is a corporate multinational specializing in agrochemicals, seeds and biotechnology, and has long been subject to global leadership in crop protection, seed research and development, and biotechnology innovation. The transaction, valued at $43 billion, represents the biggest overseas acquisition by a Chinese company in the agricultural sector so far [148].

The purchase of Syngenta holds great strategic importance for China's future. The M&A not only introduces advanced agricultural technology through foreign direct investment, but also plays a crucial role in shaping the global agricultural science, technology, and industry landscape. As a leading global biotechnology enterprise, Syngenta's R&D and production advantages in the fields of pesticides, GM seeds and agrochemicals are directly related to the key issues of crop yield enhancement and response to climate change, pests and plant diseases [92].

Table 2.18

Key details of Syngenta acquisitions

Aspect	Detail
Assignee	China National Chemical Corporation
Target	Syngenta AG (Switzerland)
Purchase value	$43 billion
Year	2017
Strategic Importance	Access to agricultural technology, presence in global markets, and environmental sustainability.

Source: Data from China National Chemical Corporation, 2017

Through this acquisition, China has not only injected innovative technologies into the domestic agricultural sector, but also effectively expanded its entry into the international market and strengthened its influence in the global agricultural market, especially in regions like Europe and North America, Syngenta has established a strong market presence and brand recognition. This strategic move not only bolsters China's competitive position in the global agricultural supply chain but also acts as a significant catalyst for Chinese agricultural products to enter developed economies' markets. In addition, the broader impact of the Syngenta acquisition on China is also reflected in the realization of sustainable development goals in agriculture. Syngenta's investment in sustainable agricultural technologies, particularly in reducing pesticide use and promoting Integrated Pest Management (IPM) systems, fits well with the Chinese government's policy objective of reducing environmental problems caused by the misuse of chemical fertilizers and pesticides in agricultural production [125]. This not only injects new vitality into China's ecological civilization building and green agricultural development, but also global sustainable development, thus further enhancing China's core competitiveness in the international agricultural market.

In addition to direct acquisitions, China is involved in with international agricultural strategy of partnership (Fig. 2.17 and 2.18).

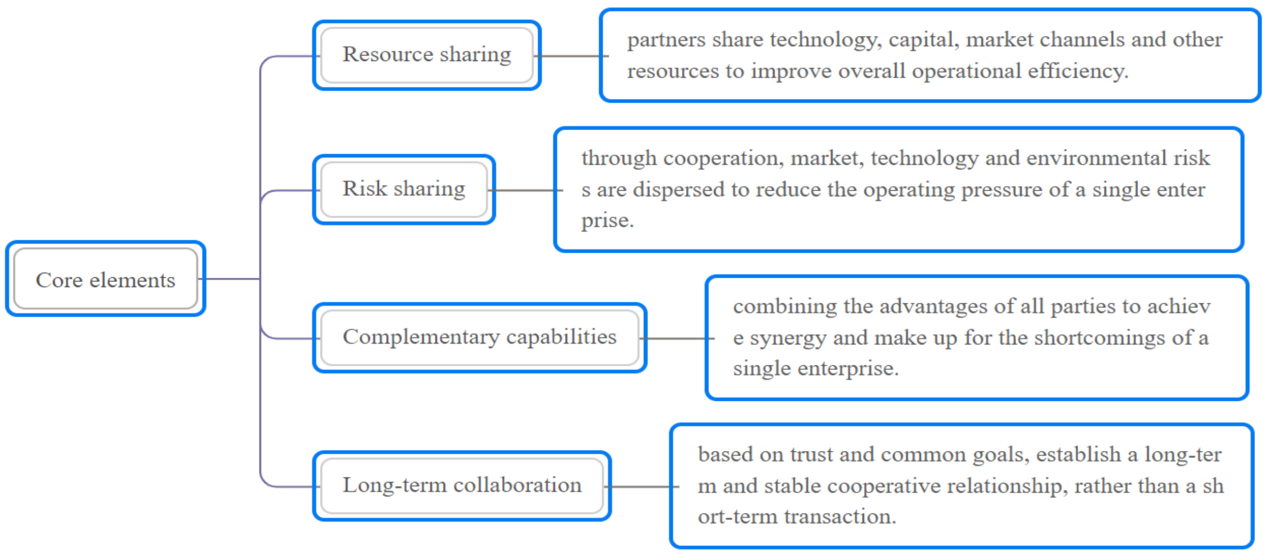


Fig. 2.17. Core elements of a strategy of agricultural partnership

Source: Organized by the author

These collaborations aim to share technology, improve production capacity and access new markets. Chinese companies often work with transnational corporations to create innovative agricultural products, increase productivity and promote environmental sustainability [116]. For example, China has partnered with prominent biotechnology companies to create genetically modified crops suitable for its agricultural environment. Collaborations with companies such as Bayer and Monsanto have enabled China to introduce high-yielding seed varieties and pest-resistant crops, greatly increasing domestic agricultural productivity. COFCO has established joint ventures with international commodity traders to expand its presence in Europe and Latin America [115]. These collaborations have enabled Chinese companies to increase their market share and influence in global agricultural supply chains. Key aspects of China's alliance with global agriculture are complementary capacities, supply chain cooperation, resource sharing and risk sharing.

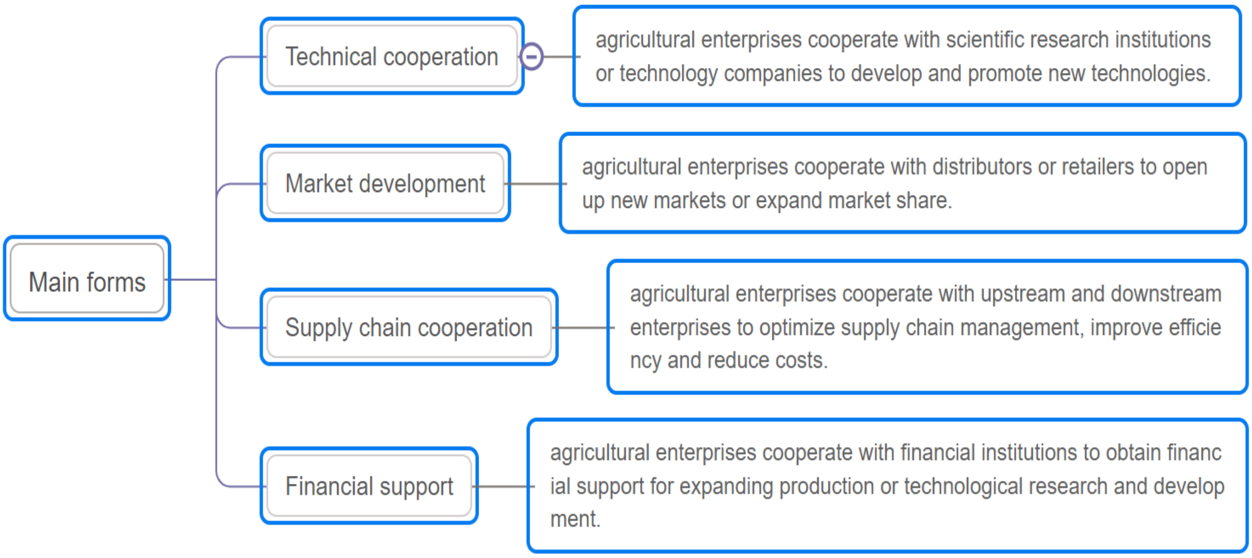


Fig. 2.18. Main forms of agricultural partnership strategies

Source: Organized by the author

China and Ukraine have a long history of agricultural cooperation, and the two sides have achieved results in many areas, including agricultural trade, investment and technical exchanges. Agricultural trade between China and Ukraine shows remarkable complementarity [63]. Ukraine has a strong foundation in agricultural science and technology, and with 25 percent of the world's black soil resources, it focuses on food production, with its wheat, corn and sunflower oil occupying an important position in the global market. China, on the other hand, is a global leader in agricultural machinery, smart agriculture and water-saving irrigation.In terms of investment in agricultural infrastructure, Chinese enterprises have invested in Ukraine in the construction of agricultural infrastructure, such as irrigation systems, storage facilities and processing plants. For example, COFCO has leased a large amount of land in the Amhara region of Ukraine for the cultivation of corn and wheat. By introducing advanced agricultural technology and management experience, the yields of corn and wheat have increased by 30% and 25% respectively. COFCO invested USD 75 million in the construction of DSSC terminal in Nikolaev Port, Ukraine, which has a total throughput of 2.5 million tons/year and a storage capacity of 143,000 tons. In addition, COFCO has become the second largest vegetable oil exporter in Ukraine through the acquisition of all the shares of Ukrainian Lai Bao Group, with an annual operating volume of 300,000 tons and a market share of 25%. In terms of investment in agricultural technology, Chinese companies are promoting advanced agricultural technologies in Ukraine, such as precision agriculture, drone technology and smart irrigation systems. Huawei has cooperated with Ukrainian companies to build smart farms, introducing IoT and big data technologies to realize precise fertilization, smart irrigation and pest monitoring.

In the field of conservation tillage technology, China has promoted techniques such as no-tillage seeding and straw return to the field, assisting Ukraine in reducing black soil erosion and enhancing soil organic matter content. For instance, Heilongjiang Agricultural Reclamation Group has collaborated with Ukrainian farms to implement conservation tillage practices, including no-tillage seeding and straw return. These initiatives have resulted in a 5-8% increase in soil organic matter content and effectively mitigated soil erosion [163]. Cooperation in digital agriculture: the two sides have cooperated in the field of digital agriculture, leveraging technologies like the Internet of Things, big data, and artificial intelligence to enhance the efficiency of agricultural production. For example, Huawei cooperated with Ukrainian agribusinesses to build smart farms, introducing IoT and big data technologies to achieve precise fertilizer application, smart irrigation, and pest and disease monitoring. Through these technologies, the farm's water utilization rate has increased by 30 percent, and yields have increased by 15 percent [236].

Cooperation in sustainable development: In the area of ecological agriculture, the two sides have cooperated in the development of biofuels from agricultural waste, converting corn stalks, sunflower seed husks and other wastes into bioenergy, which is in line with the concept of the "stock-flow" cycle of ecological economics. For example, China and Ukraine have jointly built a biomass power plant with an annual processing capacity of 500,000 tons, reducing carbon emissions by 200,000 tons per year. In terms of carbon emission reduction cooperation, the two sides have promoted precision fertilization drone technology to reduce excessive fertilization and reduce greenhouse gas emissions, while increasing crop yields. The two sides are also promoting the inclusion of agricultural cooperation projects in the international carbon credit trading system, creating both economic and ecological benefits for both sides [128].

In the area of international agricultural capital transfers, China had also implemented combining a comprehensive strategy, not only seeking resources and technology through mergers, acquisitions and cooperation, but also actively promoting agricultural development and food security in developing countries through loans and assistance. This approach not only helps host countries increase agricultural productivity, but also opens up more investment prospects and market opportunities for Chinese companies.

Launched in 2013, the Belt and Road Initiative (BRI) serves as China’s primary strategy for global infrastructure development. Through the BRI, China has made significant investments in advancing agriculture across Asia, Africa, and Latin America, focusing on improving agricultural infrastructure, enhancing food security, and increasing productivity [156]. China has financed the construction of irrigation systems, grain storage facilities, and transportation networks in these countries. These projects aim to streamline the movement of agricultural products, minimize post-harvest losses and improve farmers' access to market [151].

The Table 2.19 shows China's initiatives to support agricultural development in various countries through financial loans associated with the BRI. These projects aim to strengthen infrastructure, increase productivity, and improve food security in areas facing difficulties such as limited water resources and post-harvest losses. These initiatives illustrate how China is utilizing its financial resources to promote agricultural progress and ensure a reliable food supply for host countries and China itself [155].

In recent years, China has increasingly adopted public-private partnership (PPP) models to fund agricultural projects both domestically and internationally. PPPs involve cooperation between the public and private sectors to provide public services or implement infrastructure projects. This model integrates the social responsibilities of the public sector with the efficiency and innovation characteristic of the private sector. It is commonly employed to finance, construct, operate, and maintain large-scale projects [167].

Table 2.19

Priority Agricultural Projects Financed by BRI Loans (2016-2021)

Country	Project Description	Loan Amount (USD Million)	Key Impact
1	2	3	4
Kenya	Large-scale irrigation project in arid regions	200	Increased agricultural productivity in arid areas
Ethiopia	High-yield wheat seed distribution and training	150	Boosted wheat production and improved food security
Cambodia	Grain storage and transport infrastructure	120	Reduced post-harvest losses and improved market access
Uzbekistan	Modern farming equipment procurement	175	Enhanced mechanization and reduced labor costs

Source: Organized by the author [143]

These partnerships promote cooperation between the Government of China and private enterprises to finance and implement major agricultural infrastructure development. Public-private partnerships aim to attract foreign investment, diversify risk, and leverage private sector skills to manage complex agricultural supply chains. China has adopted the PPP model in various international agricultural projects, particularly in Africa and Southeast Asia. These initiatives often represent major undertakings requiring significant capital investment and expertise. Chinese private companies, particularly in the agribusiness and infrastructure sectors, have partnered with foreign governments to establish agro-processing facilities, logistics centers, and export routes [43]. In Tanzania, China has financed the development of an agricultural export center through a public-private partnership. The center has grain storage, processing and transportation facilities, which has enabled Tanzanian farmers to access international markets more efficiently, while also ensuring a steady supply of Chinese agricultural imports [247]. In Myanmar, Chinese agricultural machinery companies worked with local authorities to implement mechanized farming equipment as part of a public-private partnership initiative. Such efforts have increased productivity by reducing reliance on manual labor and have created new opportunities for Chinese-made agricultural machinery [129].

Table 2.20

Key China-led international agricultural PPP projects (2017-2021)

Country	Project Description	PPP Investment (USD Million)	Key Impact
1	2	3	4
Tanzania	Agricultural export hub and grain processing	300	Improved export capacity and market access
Myanmar	Mechanization and modern farming infrastructure	250	Reduced labor costs and increased productivity
Nigeria	Rice processing plants and distribution centers	200	Enhanced food security and reduced import dependence
Laos	Irrigation and rural infrastructure development	175	Increased agricultural output and reduced water wastage

Source: Organized by the author

These projects aim to promote agricultural infrastructure development, increase productivity and support food security through investment. Each initiative has played a role in promoting food security, increasing export capacity and improving agricultural efficiency in the countries concerned, highlighting China's strategic engagement in promoting sustainable agricultural development and strengthening global cooperation.

China’s participation in the global transfer of agricultural capital is also reflected in its export and collaboration on agricultural technology. This involvement supports the spread of agricultural technologies and services, the advancement of industrial machinery and equipment, and partnerships in the processing of agricultural products and foodstuffs. The primary objective is to improve the agricultural productivity of partner nations.

China's agricultural technologies and services are characterized by two-way flows, reflecting its unique position in the global agricultural value chain. In terms of technology export, China has provided developing countries with adaptable and cost-effective agricultural solutions based on its technological accumulation in hybrid rice cultivation technology, intelligent irrigation systems and agricultural mechanization equipment. Simultaneously, China has imported high-end technologies from developed countries, such as precision agriculture equipment, biological breeding technology and food processing technology, to make up for the technological shortcomings in the process of domestic agricultural modernization (Liu et al., 2023). In addition, China has exported its agricultural management experience to developing countries in the form of agricultural technology training, consulting services and demonstration projects, which not only improves the agricultural production efficiency of recipient countries, but also strengthens China's voice in global agricultural governance (Chen et al., 2022). However, the imbalance between technology export and introduction and the issue of intellectual property protection remain key challenges that constrain the sustainable development of agricultural technology trade (Ministry of Agriculture, 2023). In the future, China needs to further optimize the structure of technology trade and promote agricultural technology cooperation to a higher level.

Table 2.21 summarizes the challenges of both foreign capital entering Chinese agriculture and Chinese capital investing in overseas agriculture such as land ownership, policy instability, market risk and cultural conflict. In terms of land ownership, foreign capital entering Chinese agriculture is constrained by the collective land ownership system in rural areas, which affects the stability of its long-term investment, while Chinese capital investing overseas also faces restrictions on agricultural land in different countries, which increases the risk at the legal level. Policy instability is a common challenge for both types of capital flows, especially in policy adjustments related to food security and national interests, where investors' expectations may be affected, thus increasing investment uncertainty and risk. In terms of market risk, special Chinese agricultural market conditions expose foreign investment to higher volatility risks, while price fluctuations in global agricultural markets and the condition of agricultural infrastructure in target countries can also affect the return on Chinese capital invested overseas [169].

Table 2.21

Challenges of International Capital Transfers in Chinese Agriculture

Challenge category	Overseas investment in Chinese agriculture (foreign capital inflows)	Chinese capital investment in overseas agriculture (capital outflow)
Land ownership	China has a system of collective land ownership in rural areas, which makes it difficult for foreign investors to directly acquire land ownership and affects the long-term stability of agricultural investment.	Many countries have restrictions on agricultural land, and Chinese companies may face legal obstacles to leasing or purchasing land when investing in agriculture overseas.
Policy instability	Agriculture is critical to national food security, and governments may adjust foreign access policies, increasing investment uncertainty.	The host country may adjust its agricultural investment policies due to political, economic or environmental factors, affecting the long-term planning of Chinese enterprises.
Market risk	The fluctuations of agricultural prices, the uncertainties in the supply chain, as well as the distinctive characteristics of China's agricultural market all lead to a greater degree of investment risk.	Fluctuations in global agricultural market prices, as well as constraints in the conditions of agricultural infrastructure and supply chains in the target countries, may affect investment returns.
Clash of cultures	Foreign companies need to adapt to China's rural land contracting system, agricultural production methods and consumer market demands.	Chinese companies need to adapt to local agricultural production methods, labor systems, environmental protection requirements, and social culture to reduce operational resistance.

Source: Organized by the author

Cultural conflict, on the other hand, is a challenge that both must overcome together. Both foreign and Chinese companies need to adapt to different agricultural production models, labor management and cultural habits when operating across borders in order to avoid the resulting operational obstacles.

To summarize, international capital flows in agriculture are not only driven by the power of capital itself, but are also heavily influenced by political, legal, market environment and cultural factors, which require all parties to adopt flexible strategies to deal with these complex challenges.

Conclusion of Chapter 2

China has achieved notable advancements in the internationalization of its agricultural sector, enhancing its own agricultural productivity while contributing to global agricultural sustainability and food security through foreign investment, technical cooperation, and trade networks. Moving forward, China should continue optimizing its investment strategies, strengthening technical collaboration, and expanding market strategies to guarantee the long-term success of its international agricultural projects and enhance its global influence in agriculture. China's agricultural sector is shaped by its limited per capita cultivated land – approximately 0.10 hectares, well below the global average – and regional disparities in agricultural production. The eastern region has a more advanced agricultural sector compared to the western part, while the south primarily grows crops such as rice and sugarcane, and the north focuses on wheat and corn. These geographical and climatic differences have led to varying cropping systems, agricultural technologies, and productivity levels across the country.

China holds a crucial position in global agricultural trade, with a significant trade deficit in agricultural products, particularly land-intensive crops like soybeans and corn. The country has expanded its agricultural trade through technology introduction and investment cooperation, ensuring more stable global supply chains. Additionally, China has actively engaged in global agricultural capital transfer through direct investments, land acquisitions, aiming to secure food supply and support the development of host countries' agricultural sectors.

China's agricultural cooperation with Ukraine has been particularly significant, with Ukraine serving as a key supplier of grain and China contributing expertise in agricultural machinery, smart farming, and irrigation. Companies like COFCO have leased land in Ukraine, improving crop yields and quality through advanced technology and management practices.

Despite China's achievements in agricultural internationalization, challenges such as policy instability, land ownership issues, and market risks persist. To mitigate these risks, China should adopt flexible investment models, enhance cooperation with host countries, and promote agricultural science and technology partnerships to guarantee the long-term sustainability of its worldwide agricultural investments.

The results of the Chapter 2 are summarized in author’s papers: [66-70, 72].

CHAPTER 3.
STRATEGIC VECTORS OF INTERNATIONALIZATION IN CHINA'S AGRICULTURE SECTOR

3.1. Global Challenges of Agricultural Development and Sustainability

The globalization of agriculture has been accelerating, fueled by the increasing value of trade in key agricultural commodities and the continuous growth in trade volumes. World agriculture faces not only the emerging demands and challenges brought about by population and economic growth but also significant influences from international markets and agricultural trade dynamics. Constraints on agricultural development, are expected to intensify. Despite an overall increase in global food production capacity, the issue of global food security remains critical. Additionally, the total amount of arable land is shrinking, with limited reserve resources available, and the quality of existing farmland is at risk of severe degradation [227]. In the evolution of the global agricultural system, various factors have interacted to shape the current status and future direction of agricultural production. These factors not only affect the agricultural production capacity of countries, but also have significant implications for global food security, resource distribution, and sustainable development. [238].

The challenges facing agricultural systems are illustrated in the Fig. 3.1. Population growth is putting pressure on agricultural systems, contributing to rising demand for food and placing greater demands on agricultural production capacity. Climate change is leading to higher temperatures, shifts in rainfall patterns, and a rise in the frequency of extreme weather events, creating uncertainty in agricultural production and affecting crop growth and harvests. Water scarcity, excessive irrigation, soil erosion, overgrazing, and inadequate farming practices are all contributing to the unsustainability of agricultural systems, resulting in lower land productivity and environmental degradation [172]. To address these challenges, agricultural systems need to adopt precision agriculture and biotechnology, implement sustainable farming practices, develop precision irrigation systems, conservation agriculture and organic fertilizers to improve productivity and resource use [59]. International exchanges and cooperation are particularly important, with China's Belt and Road Initiative sharing agricultural innovations to vulnerable regions and helping to address pressing food security challenges. Global governance, policy frameworks, education, along with strategies to minimize chemical input usage, promote crop diversification, and implement integrated pest management, have been crucial in mitigating resource scarcity and biodiversity loss [194].

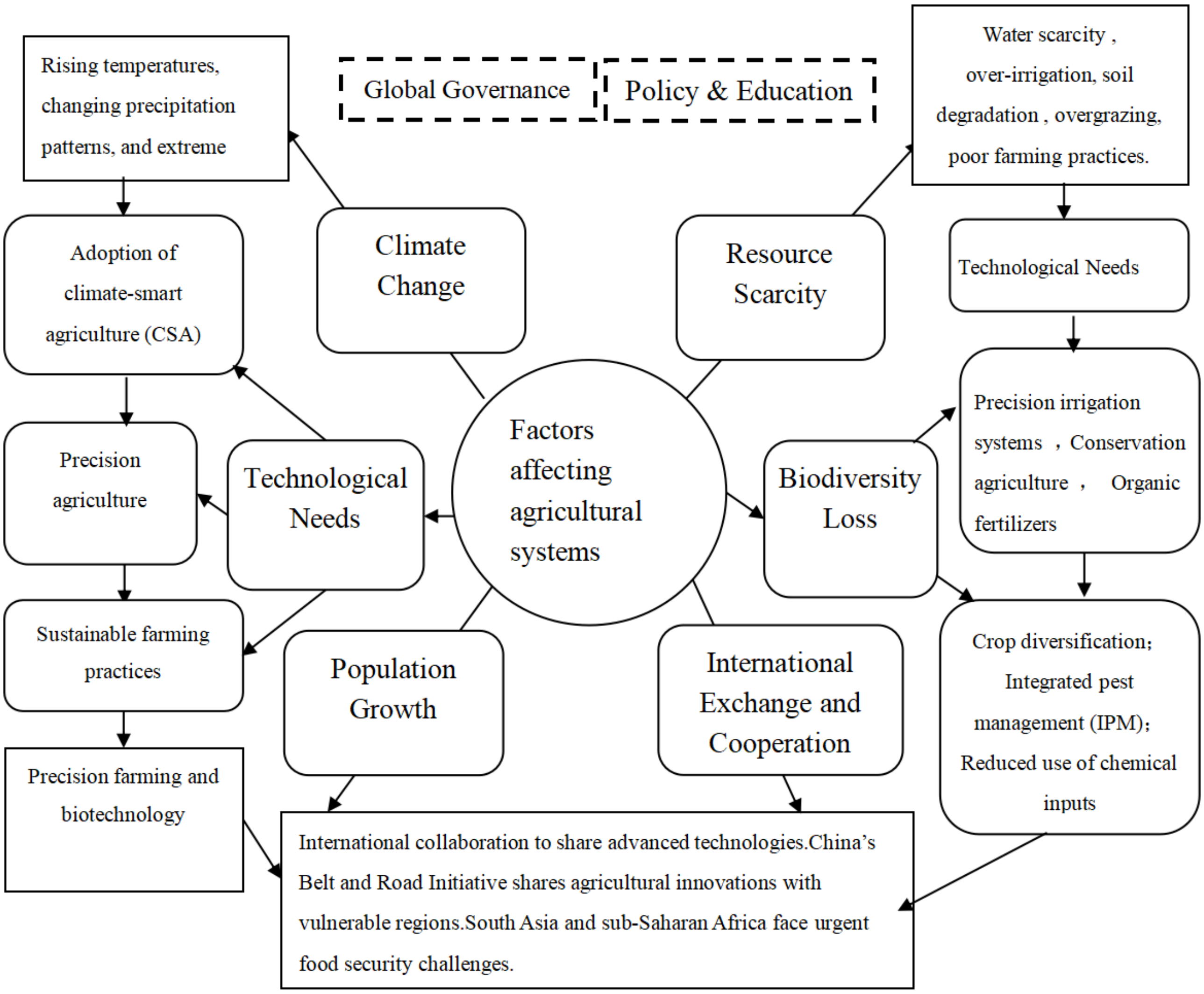


Fig. 3.1. Challenges facing agricultural systems

Source: systematized by the author

Global agricultural development and sustainable growth are confronted with numerous significant challenges. The transformation of agriculture must follow the path of sustainable development, ensuring food security, preserving ecological balance, and addressing climate change. In order to ensure global Despite the enormous efforts made, devastating factors remained in reality, for example, by nations to enhance agricultural efficiency, improve resource allocation, and minimize environmental effects that are behind schedule [18].

Agricultural productivity is struggling to support the rigid demands of a growing human population. By 2050, the global population is expected to reach 10 billion, representing a 50 percent increase from 2013. As a result, the demand for food and other agricultural products is anticipated to grow by 50 percent over the same period, driven by population growth, higher per capita incomes, and rapid urbanization [49]. However, the natural resources on which agricultural production depends are diminishing or even disappearing in a non-renewable manner every year. Therefore, existing improving the livelihoods of the highest proportion of small-scale farming households in sustainable manner is the most serious challenge facing global agriculture in the future.

Natural resources essential for sustainable development are becoming increasingly constrained and their quality is declining. Projections indicate that by 2050, global agricultural land, water resources, forests, capture fisheries, and biodiversity will face mounting pressure. The additional land needed for future agricultural production is estimated to be around 100 million hectares. While the demand for new agricultural land will remain minimal in high-income countries, low-income countries will bear the brunt of this need. However, these nations face significant challenges in accessing suitable land due to inadequate infrastructure and geographic isolation [188]. Simultaneously, resources such as forests, oceans and living organisms are becoming increasingly scarce with the accelerating global urbanization, industrialization and townships, and the rapid intensification of production of inland aquaculture, biomass energy, non-food raw materials and forestry. Water scarcity is expected to become an escalating constraint, especially in regions that rely heavily on irrigation. Future water stress will be influenced not only by changes in demand but also by variations in water availability and altered precipitation patterns due to climate change, among other factors. In addition, pollution of water resources, soil acidification and heavy metal pollution, and atmospheric pollution are growing problems. Soil and water degradation due to resource scarcity is one of the most pressing resource challenges for agricultural development. Agriculture accounts for nearly 70% of global freshwater extraction (FAO, 2020), and over-irrigation is leading to water depletion, especially in arid and semi-arid regions. Soil erosion and degradation - caused by deforestation, overgrazing and poor farming practices – further limits global food production. The World Bank (2021) reports that as much as 52 per cent of the world's agricultural land is affected by soil degradation, which threatens long-term food security.

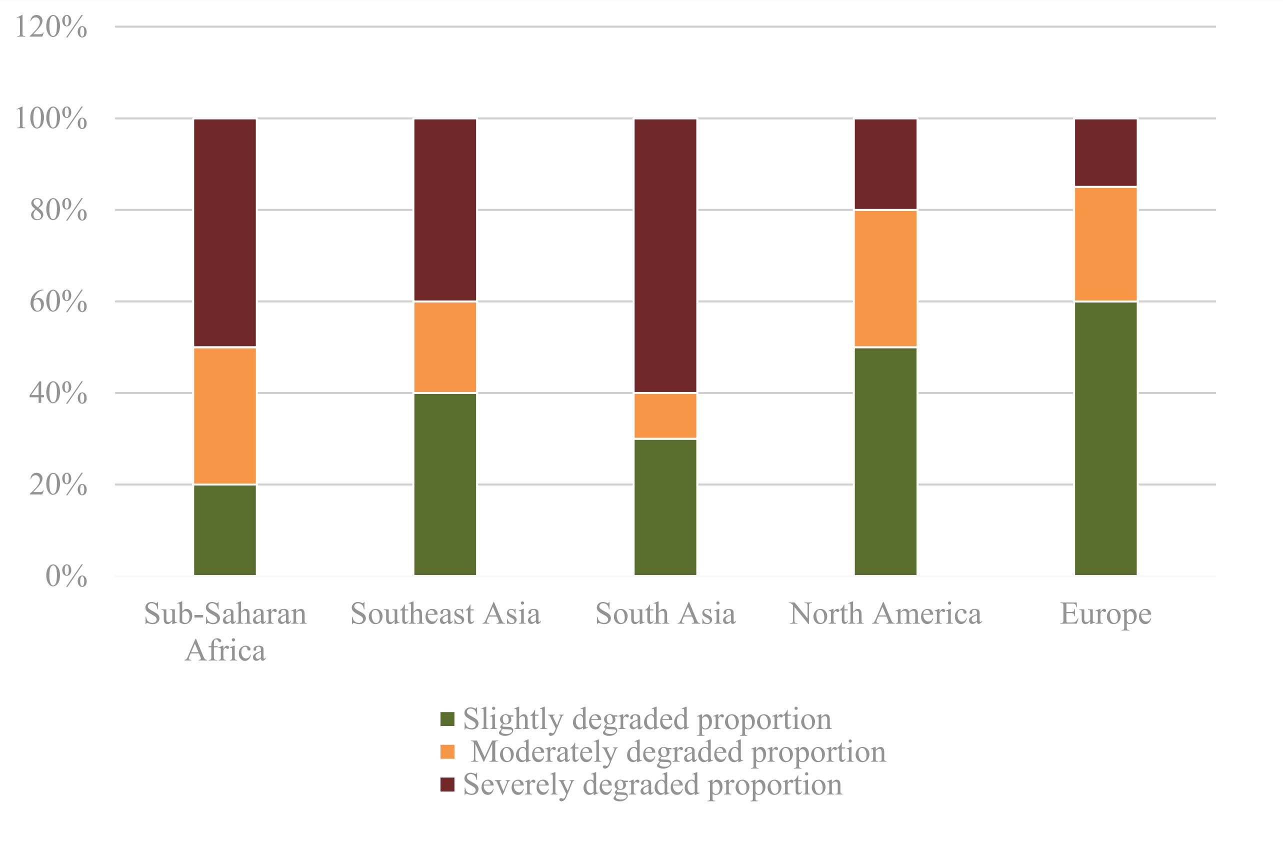


Fig. 3.2. Soil degradation degree in different regions

Source: FAO

As illustrated in Fig. 3.2, the extent of soil degradation across various regions is categorized into three classes: mild, moderate and severe degradation [176]. It is evident that sub-Saharan Africa and South Asia are experiencing the most severe soil degradation issues, with a significantly higher proportion of severe degradation than the other regions. Southeast Asia has a higher proportion of moderate degradation, while North America and Europe have relatively mild soil degradation, mainly dominated by mild degradation. This data reflects the uneven distribution of soil health globally and highlights the need for urgent conservation and rehabilitation measures in areas of severe soil degradation in order to achieve sustainable agricultural development.

To address these challenges, many countries, including China, have turned to "sustainable agricultural practices" and "innovative technologies" to mitigate the effects of "water scarcity" and "soil degradation"[24]. One such method is the implementation of "precision irrigation systems," which enhance water efficiency by providing crops with the exact amount of water they require, thus reducing waste. This technology is particularly beneficial in "arid and semi-arid regions" where water is scarce[4]. Research has demonstrated that precision irrigation can cut water usage by as much as 30% while either maintaining or potentially boosting crop yields. Similarly, the use of "drip irrigation" and "rainwater harvesting" techniques, as these methods further promote water conservation and ensure that crops receive sufficient water during the critical growing period [242].

As shown in the Table 3.1, the differences in the adoption of water-saving technologies across various regions are highlighted. The data show that developed regions such as Australia and North America have a high utilization rate of efficient irrigation systems, at 70% and 60%, respectively, indicating that these regions have invested heavily in water management and agricultural technologies, and have well-developed infrastructures and technical support. In contrast, sub-Saharan Africa and South Asia have relatively low rates of utilization of efficient irrigation systems, at 30% and 50%, respectively, reflecting the lack of infrastructure, financial constraints, and difficulties in accessing technology in these regions. Inefficient water use in agriculture in these regions leads to wastage of water and reduced agricultural productivity, especially in the face of challenges such as drought brought about by climate change, which makes it necessary to improve the efficiency of irrigation systems. Overall, the data in the table indicate that the adoption of efficient irrigation technologies is strongly linked to the level of regional economic development and the quality of agricultural infrastructure [122].

Exacerbated by climate change and natural disasters. Climate change, compounded by natural and human-induced disasters, is causing significant damage to agricultural production, leading to the degradation of land, forests, water, fisheries, and other natural resources, while also diminishing overall productivity. The impact of climate change on food security and human livelihoods is becoming increasingly severe, with projections indicating that by 2050, climate change could result in an additional 2 billion undernourished people worldwide, more than half of whom will be in sub-Saharan Africa. As a result of climate change, extreme droughts and floods are expected to intensify and occur more frequently, while rising temperatures and extreme weather events will contribute to the spread of certain human diseases. In sub-Saharan Africa, efforts to promote climate-smart agriculture are focused on enhancing resilience to climate change. Programs like the Africa Climate-Smart Agriculture Coalition aim to assist smallholder farmers in adopting practices that improve soil health, conserve water, and boost productivity despite the changing weather patterns brought on by climate change.

Table 3.1

Global distribution of efficient irrigation systems

Area	**Proportion of irrigated land using efficient irrigation systems (%)**
Middle East	45%
Sub-Saharan Africa	30%
South Asia	50%
Europe	55%
North America	60%
Australia	70%
Global average	50%

Source: systematized by the author based on [112]

The challenge of eradicating extreme poverty and reducing inequality remains formidable. While global economic growth in the past three decades has led to a significant reduction in poverty, about 2.1 billion people still live in poverty, with 700 million of them in extreme poverty. Most of the world’s poor and malnourished populations reside in underdeveloped rural areas, where they depend on agriculture, fisheries, and forestry for their livelihoods. Food costs represent a large portion of the budgets of these impoverished households, making food security a vital component in combating poverty and hunger. Furthermore, inequalities between rural and urban areas, across regions, among ethnic groups, and between genders are widespread around the world [177].

Achieving the objective of eradicating hunger and all forms of malnutrition presents a substantial challenge. Population growth is also a key factor influencing agricultural development. By 2050, the global population is expected to rise to 9.7 billion, resulting in a 60% increase in food demand [107]. This growth places immense pressure on the agricultural sector to increase production with fewer resources. Areas experiencing the most rapid population growth, such as South Asia and Sub-Saharan Africa, are especially vulnerable to food shortages unless innovative agricultural solutions are adopted [81]. The global population is expected to grow primarily in countries that are already experiencing high levels of food insecurity. In low-income nations, this population increase will significantly raise the demand for staple crops such as roots, tubers, and plantains. Simultaneously, many countries are confronted with the "triple burden" of malnutrition, which includes undernutrition, micronutrient deficiencies, and issues like overweight and obesity. Different forms of malnutrition can coexist within the same country, household, or even individual. Raising per capita income is essential to addressing malnutrition effectively, as income growth will lead to a shift in dietary patterns, increasing the demand for animal products, as well as foods rich in fats and sugars, while reducing reliance on cereals, milk, and meat products.

Table 3.2

Population growth forecasts

Year	Global Population (billion)	Growth rate (%)	Population South Asia (billion)	Population Sub-Saharan Africa (billion)
2021	7.9	-	1.9	1.1
2025	8.1	2.5	2.0	1.3
2030	8.5	4.9	2.2	1.5
2035	8.8	3.5	2.4	1.8
2040	9.1	3.4	2.6	2.1
2045	9.4	3.3	2.8	2.5

Source: Compiled based on the United Nations World Population Prospects

As shown in the table, the projected global population is described in detail, emphasizing significant growth, which are particularly vulnerable to food shortages due to rapid population growth. The table includes specific figures for the populations of South Asia and sub-Saharan Africa, as well as estimated annual population growth rates for each region. This data underscores the pressing challenges faced by these regions in ensuring food security in the face of growing populations, emphasizing the urgent need for innovative agricultural solutions and international cooperation to improve productivity and resource management.

Food systems must improve their efficiency, inclusivity, and adaptability. The global food system is undergoing significant changes, with many regions increasingly reliant on global supply chains and large-scale distribution networks, such as supermarkets. While more efficient food systems bring benefits, they also present new challenges. These include the proliferation of calorie-dense, low-nutrient foods, limited market access for small-scale producers, high levels of food loss and waste, and concerns about food safety and the health of plants and animals. These factors are expected to significantly affect future food and nutrition security. For many low- and middle-income countries, integrating local food systems with urban growth and capitalizing on market opportunities will prove challenging. Urban populations often demand high-value foods like fruits, vegetables, and dairy products, which are labor-intensive and typically produced by small-scale farmers. Strengthening the connection between these farmers and urban centers is crucial for enhancing their capabilities. Additionally, due to management and technological limitations, food losses during storage, transportation, processing, packaging, and marketing tend to be higher in low-income countries, while food waste during consumption is more prevalent in middle- and high-income nations [186].

Brain drain from agricultural labor migration is a growing problem. Widespread global inequality has resulted in higher numbers of rural people trapped in hunger and poverty, a reluctance of young people in rural areas of many low-income countries to engage in agricultural labor, and high levels of internal and international mobility or migration. Most women and older people remain in rural agriculture, but their limited ability to access and improve resources constrains increases in labor productivity. A major global challenge in the coming decades will be integrating hundreds of millions of young people into the labor market. The aging population is projected to increase from around 1 billion in 2015 to 1.2 billion by 2050, with the growth concentrated in sub-Saharan Africa and South Asia [20]. Moreover, the movement of people plays a crucial role in the process of economic growth and structural transformation in today's societies and will accelerate dramatically in the coming decades, both within and between victimized countries, with significant impacts on agriculture, both locally and in destination countries.

Mechanisms to respond effectively to crises, disasters and conflicts are imperfect. In many countries, protracted crises are a key factor affecting the eradication of hunger, malnutrition and poverty. The recurring crises are primarily caused by both natural and human factors, including violent conflict, food shortages, the collapse of livelihoods and food systems, weak governance structures, or a combination of natural disasters and human-induced events, all of which contribute to prolonged crises. Currently, nearly half a billion individuals across over 20 countries and regions are impacted by these ongoing situations, with the majority located in Africa. The intensity and frequency of conflicts and disasters have increased globally in recent decades, and conflicts, protracted crises and natural disasters have also contributed to displacement and migration flows.

Transboundary plant and animal pests and diseases are frequent, recurrent and concurrent. In recent years, the intensification of climate change, along with the acceleration of globalization and trade facilitation, has resulted in more frequent, recurrent, and concurrent outbreaks of transboundary plant and animal pests and diseases. This has led to a steady increase in agricultural hazards and losses, posing a significant threat to food security, as well as the stability of the agriculture industry and global trade. In the face of frequent outbreaks of transboundary animal and plant diseases and pests, the international community generally lacks an effective coordination mechanism and preventive capacity [46]. In addition, foodborne diseases and chemical contamination of food are on the rise, antibiotic resistance is becoming increasingly serious, and the risk of food insecurity has increased due to insufficient security and inspection facilities and capacity and ineffective law enforcement in food processing, storage, transportation and other processes. The animal health system, plant health system and food safety system lack an effective mechanism to integrate and coordinate with each other [200].

The absence of cohesive agricultural governance systems, both nationally and internationally, exacerbates the challenges in food and agriculture. Addressing these issues requires not only integrated policies at the national level but also coordinated global collaboration. The United Nations 2030 Agenda for Sustainable Development, along with other relevant global frameworks and agreements, emphasizes the importance of aligning global and national policies with actions aimed at achieving these goals [80]. Successful global governance demands more inclusive policy choices and dialogue frameworks, especially to avoid marginalization of politically weak countries from decision-making. Increasing competition for natural resources could lead to the deprivation of the rural poor of the basis of their livelihoods, especially in in crisis situations sustainable development areas where and conflicts and disasters were common, and ensuring the rights of the poor to access to and use of natural resources.

In 2015, the United Nations launched "Transforming Our World: The 2030 Agenda for Sustainable Development," which delineates 17 Sustainable Development Goals (SDGs). These goals aim to address critical global challenges, such as poverty, inequality, climate change, and environmental conservation, offering an international cooperative strategy designed to guide future actions for the well-being of humanity and the planet [35].

Sustainable development in agriculture is a key principle for ensuring food security, enhancing resource utilization efficiency, safeguarding the ecological environment, and fostering long-term agricultural growth. The primary concerns of sustainable agricultural development include the following:

Agro-industry has become the world's an important engine for the development of economy. Some data show agricultural that in developing countries, agro-industry contributes 61 per cent to manufacturing in agriculture-based countries, 42 per cent in countries in transition, and 37 per cent in countries with urbanized development [7]. In developing countries, agro-industries have a particularly significant impact in expanding value chains, creating jobs and reducing poverty and hunger. In order to replace oil resources, which are expensive and non-renewable, the United States and Europe have been producing large quantities of biomass fuels from food and oil, which has triggered a rapid rise in food and oil prices. In the long term, this model is not sustainable. As a result, the United States, Europe, and other nations are expediting the development of second-generation biomass fuel technology, which utilizes non-food and non-oil raw materials, to gain a competitive advantage in biomass fuel technology. With the rapid pace of economic globalization, the investment of multinational corporations in the agricultural sectors of developing countries is increasing at a significant rate. Consequently, worldwide integration of resources and global value chain innovation are realized, and trade barriers can be bypassed and trade friction reduced [22]. The merger and acquisition of many of China's leading agricultural product processing enterprises by foreign investors is a good example of increased investment by multinational corporations in the agricultural industry. Although developing countries do have abundant agricultural labor resources, they cannot develop well because of the low quality of labor. To address the issue of the shortage of high-quality personnel, it has become inevitable to increase the development of rural human resources.

Agricultural trade is strongly interconnected with regional food security. The majority of the world's arable land is concentrated in Asia and the Americas. However, per capita arable land is more abundant in Oceania and North America, whereas it is more limited in Asia, particularly in South Asia and East Asia. In 2017, the worldwide per capita arable land availability amounted to 0.18 square hectometers (hm^2), while per capita arable land in Oceania, which has the smallest area of arable land, was as high as 0.78 hm^2, and per capita arable land in North America was also higher (0.54 hm^2). Asia, especially East Asia, has lower per capita arable land of only 0.11 hm^2 per capita . The imbalance between global water supply and demand will be further exacerbated in the context of climate change with the increase in water use by industrial societies and internationalization, among others [158]. From a supply perspective, the overall availability of surface water resources is expected to remain stable, although the spatial disparity will intensify. The global extraction of groundwater resources will rise sustainably, while the over-exploitation of groundwater in certain regions will become more pronounced. From the analysis of global arable land and water resources distribution characteristics and change trends, it can be observed that the disparity in the distribution of the world's arable land and population indicates the variations in the structure of agricultural production and the significance of trade. For instance, China possesses 8% of the world’s arable land but holds 20% of the global population, which results in its land-intensive agricultural products being less competitive in international markets. Agricultural product and food trade are a crucial strategy for addressing food security both globally and within individual nations. Countries with less than 0.12 hm^2 of arable land per capita, like China, primarily rely on imports for agricultural products and food. In contrast, nations such as Germany, which maintain a balance between imports and exports of agricultural products and have more than 0.26 hm^2 of arable land per capita, play a different role in the global trade landscape. International trade in agricultural products is essential for balancing supply and demand, as well as addressing disparities in resource availability among different regions of the world [131].

Global food production: Patterns, geographical distribution, and advancements in productivity. Although the global cereal area has shown a declining trend, total cereal production has been increasing. The growth in total cereal production is mainly due to the increase in cereal yields. Studies have shown that the increase in yields is mainly due to two factors: one factor is the increase in production inputs, such as fertilizers, agricultural equipment, and machinery; and the other factor is technological progress. The growing reliance on agricultural inputs has led to a range of issues. In China, the use of fertilizers and pesticides continues to rise, in contrast to many European nations that began scaling back such inputs as early as the 1980s. Significant disparities exist in cereal yields across different regions, indicating considerable untapped potential in global cereal output. At present, around 50% of the world's cereal production comes from countries where the average yields are below 5 tons per hectare. Meanwhile, nations with yields exceeding 6 tons per hectare contribute only about 20% to the total global production. This suggests that raising productivity in lower-yielding regions could lead to substantial increases in overall output. In fact, there remains strong potential for global food supply expansion, especially if yield improvements can be achieved in underperforming areas. For China and many other countries, future agricultural development will heavily rely on enhancing productivity. Furthermore, safeguarding China's food security will require greater focus on boosting agricultural production in developing nations. In recent decades, the global food supply has grown substantially, reaching approximately 2.8 billion tons in 2023 [223]. As the global population continues to rise, food demand is projected to grow by nearly 50 percent by 2050, further increasing pressure on agricultural production. Additionally, agriculture remains the world's largest employment sector, with approximately 38% of the global labor force engaged in agriculture. In developing countries, this proportion exceeds 55% [77]. Moreover, the proportion of agricultural output in the global economy has been steadily rising, with global agricultural production estimated at $3.2 trillion in 2023, representing 4.8% of global GDP. Concurrently, agricultural trade has become a significant component of global commerce, with the value of global agricultural trade reaching $2.33 trillion in 2023, accounting for 11% of total global trade [8].

As shown in the Fig. 3.3, the data of the top ten countries in global food production in 2023 can be clearly displayed. China tops the list with 680 million tons of production, demonstrating its strong agricultural productivity, while the United States, India, Russia and Brazil follow. Indonesia, Canada, Ukraine, France and Argentina also figure prominently in global food production, together providing significant support for global food security.

Scientific and technological advancements are key drivers of progress in agriculture. Globally, public investment in agricultural research and development (R&D) has consistently increased, with high-income countries contributing more than half of the total public R&D funding in agriculture. In recent years, however, developing nations have seen their public agricultural R&D spending grow at a rate on par with or even surpassing the global average. This emerging wave of technological innovation and industrial transformation is injecting new energy into the modernization and restructuring of the agricultural sector. Agriculture is increasingly entering a new era marked by modernization, where information technology plays a central role, and developments such as bioengineering, smart farming, and sustainability are key driving forces. This wave of technological innovation has triggered a deep and far-reaching transformation in global agriculture, reshaping not only how agricultural goods are produced but also how they are traded across international markets [108].

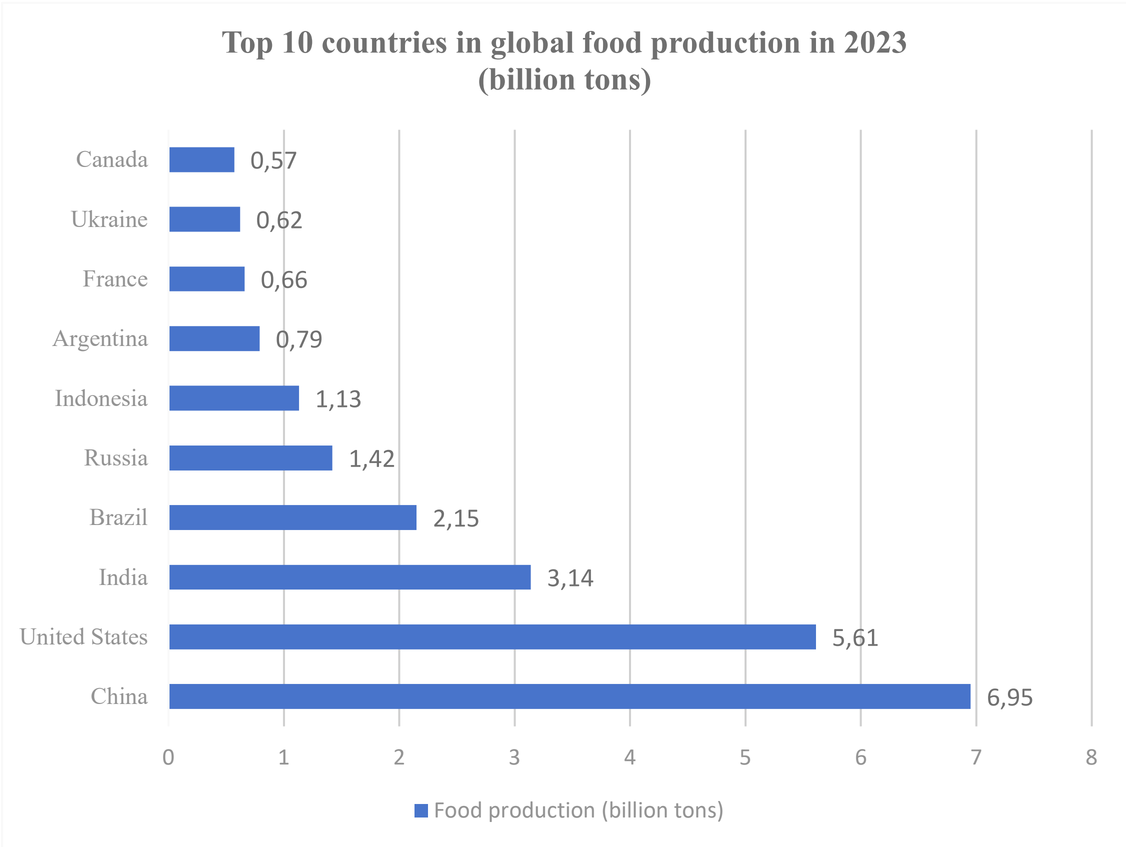


Fig. 3.3 Top 10 countries in global food production in 2023(billion tons)

Source: FAO

Considering global trends in agricultural science and technology innovation, China should prioritize strategic investment in sustainable agriculture and integrated approaches to address agricultural and related challenges. Emphasis should be placed on leveraging modern tools – such as biotechnology, information and communication technologies, advanced agricultural machinery, and resource management systems – to tackle issues facing agricultural development on a global scale. Key areas of focus should include addressing the interconnected challenges within the food-water-soil-energy nexus, adopting a holistic "food system" perspective to guide agricultural strategies, and accelerating the advancement of smart farming technologies.

Trends in Agricultural Support Policies in Major Developed Countries Worldwide. There have been significant changes in the agricultural support and protection rates of developed countries, and policies have gradually tended to be market-oriented and to improve agricultural competitiveness. The average producer support estimate (PSE) in countries of the Organization for Economic Co-operation and Development (OECD) has generally shown a slow decline, influenced by the Uruguay Round trade negotiations and the constraints imposed by the World Trade Organization (WTO) rules. This trend is also aimed at enhancing the market competitiveness of major agricultural products and adjusting production structures. Interestingly, this trend contrasts with China’s situation, where the PSE as a percentage of agricultural output has recently surpassed the OECD average. Furthermore, since 2009, China’s agricultural protection rate – the difference between domestic and international prices – has exceeded that of both the United States and the European Union. Looking ahead, agricultural support policies are expected to transition from direct market intervention to a focus on improving agricultural productivity, product competitiveness, and sustainable development. While developed nations continue to provide substantial agricultural subsidies, their support policies are gradually shifting away from direct price interventions towards strategies that foster greater competitiveness in their agricultural sectors.

All countries are seeking agricultural development models that suit them to ensure food security and foster sustainable agricultural development. The United States Precision Agriculture, the European Union Green Agriculture and the African Food Security Program, as representative agricultural development models, have accumulated rich experience in addressing food security and sustainable development.

In the United States, precision agriculture leverages advanced technologies and big data to enhance production efficiency and minimize resource use. This technological innovation incorporates tools such as satellite remote sensing, geographic information systems, and the Internet of Things, which allow for real-time monitoring of soil conditions and crop development on farmlands [192]. In terms of data-driven, U.S. precision agriculture makes full use of big data analysis to provide farmers with scientific advice on planting, fertilizer application, irrigation, etc., and improve agricultural production efficiency. In terms of policy support, the U.S. Farm Bill also encourages farmers to adopt sustainable farming methods, such as conservation tillage and crop rotation, by utilizing ecological subsidies, integrating policy support with technological innovation to foster sustainable agricultural development. In terms of agricultural education, the United States focuses on the cultivation of agricultural personnel and improving the scientific and technological literacy of farmers, so that they can better apply precision agriculture technology.

As shown in the Table 3.3, precision agriculture has a wide range of benefits that can reduce resource waste, lower costs, reduce the environmental impact of fertilizers and pesticides, promote sustainable agriculture and increase overall productivity. However, these technologies require significant investment and infrastructure, which is a challenge for smallholder farmers in developing countries. Sustainable agriculture is not only about the environment, but must also bring socio-economic benefits. Fair trade, rural development and the equitable distribution of agricultural benefits were central to ensuring that the global food system was not only productive but also just [197].

The European Union aims to decrease the use of pesticides and chemical fertilizers while advancing organic farming through its "farm-to-table" strategy and the Common Agricultural Policy. It has set targets to reduce chemical fertilizer use by 20% and pesticide use by 50% by 2030. In terms of agricultural ecological compensation, the European Union has implemented an ecological compensation policy for farmers, encouraging them to take environmental protection measures, such as crop rotation, fallowing, and reducing the use of chemical fertilizers and pesticides [110]. Regarding the structural adjustment of the agricultural sector, the EU encourages the transformation of the agricultural industry and promotes diversified agricultural development, including leisure and tourism agriculture, to enhance the added value of agriculture. In terms of agricultural science and technology innovation, the EU has increased its support for agricultural science and technology innovation, promoted biotechnology, organic agriculture and other green agricultural technologies, and enhanced the resilience of the agro-ecosystem through financial incentives and biodiversity protection measures, while improving the competitiveness of its agricultural products in the global market. In terms of agricultural policy guidance, the European Union has guided farmers to transition to green agriculture through the formulation of green agricultural policies.

Table 3.3

Benefits of Precision Agriculture

Benefits	Specific performance	Data/Indicators
Increase yields	Optimize crop growth conditions through precision fertilization and irrigation.	Increase in production by 10%-20%
Reduce resource waste	Accurately control the application of water, fertilizers and pesticides to prevent excessive input.	Save water by 30%-50%
Reduce costs	Reduce unnecessary resource input and reduce production costs.	Reduce production costs by 15%-25%
Reduce environmental impact	Minimize the excessive application of fertilizers and pesticides to alleviate soil and water pollution.	Reduce fertilizer use by 20%-30%
Improve decision-making efficiency	Use big data and sensors to monitor farmland conditions in real time and provide scientific decision-making support.	Shorten decision-making time by 50%
Enhance risk resistance	Reduce the risks brought by climate change and pests and diseases through precise prediction and monitoring.	Reduce risk losses by 20%-40%
Improve soil health	Sustain soil fertility and structure by implementing precise fertilization techniques and crop rotation strategies.	Increase soil fertility by 15%-25%
Promote sustainable agricultural development	Promote sustainable development of agriculture through efficient resource utilization and environmental protection.	Reduce carbon emissions by 10%-20%

Source: [110]

Through climate-smart agriculture strategies, African countries have promoted drought-resistant crops and water-saving technologies to enhance the climate adaptability of agriculture. In terms of increasing agricultural production inputs, African Governments have increased agricultural production inputs to improve agricultural production capacity in terms of promoting agricultural technologies [154]. African countries have actively promoted agricultural technologies, to increase crop yields. In terms of improving agricultural infrastructure, African governments have increased investment in agricultural infrastructure to improve agricultural production conditions. In terms of agricultural policy support, African governments have formulated a series of agricultural policies, such as reducing or waiving agricultural taxes and providing agricultural credit, to encourage farmers to develop agricultural production. International cooperation and smallholder support programs have helped African farmers to acquire modern equipment and technology, enhancing food security. These measures have laid the foundation for sustainable agricultural development in Africa.

Countries such as India, Brazil, Australia, and Israel are also proactively adapting and exploring agricultural development models tailored to their specific needs in order to ensure food security and promote sustainable agricultural growth. India has taken positive steps in water management and modernization of agriculture, promoting drip and micro-irrigation technologies to cope with drought and increasing food production through the National Food Security Programme. Technological innovations in genetically modified crops and high-yielding seeds have increased India's resilience to climate change, despite the challenges of land fragmentation and inefficiency of small farms. Brazil has promoted no-till agriculture, land restoration and biochar technology to reduce greenhouse gas emissions through a low-carbon agriculture plan and forest conservation policies. Brazil has also implemented sustainable animal husbandry measures to balance agricultural production with ecological protection, providing a viable model for low-carbon agriculture globally. Australia has excelled in water management, optimizing agricultural water use through drip irrigation technology and a strict water rights system, and promoting climate-smart agriculture to improve resilience to weather extremes. These measures have helped Australia to sustain production under drought conditions while reducing resource dependence. Israel was a leader in agricultural technology innovation, particularly in drip irrigation and water recycling technologies. Its water-efficient technologies had made desert agriculture possible and provided valuable lessons for water-scarce countries around the globe [50].

As illustrated in Figure 3.4, the effectiveness of strategic agricultural measures implemented in each country and their impact on improving sustainability and productivity is shown. Israel has the highest effectiveness score of over 90 per cent, which can be attributed to its advanced use of agricultural technologies such as drip irrigation and water recycling to optimize scarce water resources.

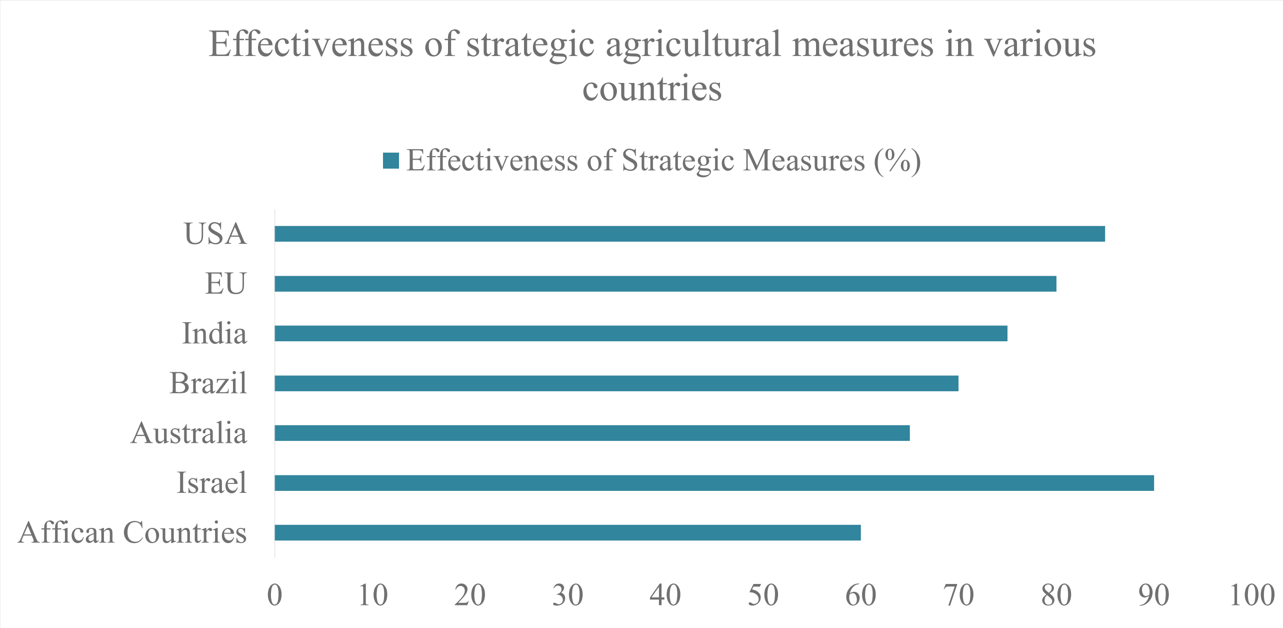


Fig. 3.4. Effectiveness of strategic agricultural measures in various countries

Source: FAO

The United States and the European Union also achieve high effectiveness scores, ranging approximately from 80 to 85 percent, due to their use of precision agriculture, ecological subsidies, and sustainable agricultural practices. Brazil, which focuses on low-carbon agriculture and forest conservation, scored moderately high at 70 percent, reflecting its efforts to balance high agricultural output with environmental protection. India and Australia have similar levels of efficiency, around 65-75%, likely due to their focus on water-saving technologies and climate-smart agriculture, which is important in their drought-prone regions. African countries scored the lowest at 60%, which highlights the continuing challenges in promoting climate-smart and sustainable agricultural practices, despite significant progress through international cooperation and support from smallholder farmers. The varying achievements of different countries highlight the environmental, technological and policy challenges faced by different regions in achieving sustainable agricultural growth.

Driven by the trend of globalization, the process of internationalization of agriculture has continued to accelerate, and with the help of trade, investment and technological cooperation, countries have been able to deeply embed their own agriculture into the global economic system, and have gradually formed an international mode of division of labor based on comparative advantages. However, the deepening of agricultural internationalization does not only depend on the independent operation of national agricultural production, but also on an efficient and stable global agricultural supply chain, which plays an indispensable supporting role. The agricultural supply chain, a crucial link between production and consumption, spans the entire process from production to market, encompassing planting, breeding, processing, transportation, storage, and marketing. It not only influences the efficiency of agricultural product circulation but also has a direct effect on the extent of agricultural internationalization. Consequently, as agriculture becomes increasingly globalized, agricultural supply chains worldwide must become more adaptable, resilient, and sustainable to effectively navigate the growing complexity of the international landscape and shifting market demands. In recent years, global agricultural supply chains have faced unprecedented challenges. Factors such as epidemics, wars and extreme weather have had a huge impact on agricultural supply chains, leading to growing problems of food security, price volatility and supply chain stability.

The outbreak of the New Crown epidemic has had a profound impact on the global agricultural supply chain [207]. On the one hand, the epidemic led to the disruption of global agricultural trade, increased transportation costs and reduced logistical efficiency. For example, the embargo measures taken by countries during the epidemic led to a shortage of truck drivers, a decline in the operational efficiency of ports, and even the closure of some factories due to the epidemic. In addition, the epidemic also exacerbated the imbalance between supply and demand of agricultural products, with some of them stagnating during the prime selling period, such as a significant drop in consumption of dairy, meat, aquatic products and flowers. On the other hand, the epidemic also had an impact on agricultural production and labor, and agricultural production in many countries was affected by labor shortages, which in turn affected the production and supply of agricultural products.

The impact of war on the agricultural supply chain is mainly reflected in two ways: first, the destruction of land and damage to infrastructure caused by war, which reduces agricultural production capacity. For example, after the outbreak of the Russian-Ukrainian conflict, Ukraine, a globally important grain exporter, had its ports blocked, resulting in large quantities of grain not being exported. It is estimated that Ukraine supplies about 45 million tons of grain to the global market each year, 90 per cent of which is exported by sea, and the conflict directly led to the blockage of its export corridors. Secondly, refugee flows and population movements triggered by the war have led to a reduction in the agricultural workforce and a severe impact on agricultural production [100].

Extreme weather events are having an increasing impact on the agricultural supply chain. Frequent occurrences of extreme weather conditions, such as droughts, floods, and typhoons, have resulted in lower crop yields and worsened agricultural production conditions. According to the Food and Agriculture Organization (FAO), since 2009, the likelihood of extreme weather events like droughts and heatwaves has been significantly higher compared to the 1980s and 1990s, which has profoundly affected global food production. Moreover, climate extremes also disrupt the transportation and storage of agricultural goods, further intensifying food security challenges [213]. For example, heavy rains and floods not only damage agricultural infrastructure, but also cause disruptions in the transportation of agricultural products, further affecting the stability of supply chains.

These shocks have shown that global agricultural supply chains are exposed to significant vulnerabilities in the face of unexpected events such as epidemics, wars and climate extremes, and that future uncertainties need to be addressed by improving the flexibility, resilience and sustainability of supply chains.

Faced with the worldwide challenges of agricultural advancement and sustainability, nations globally acknowledge that ensuring global food security demands more than the efforts of a single country. It calls for international collaboration, policy alignment, and a tangible emphasis on global agricultural partnerships, which is highlighted in four areas: complementarity of resource advantages, strengthening of the capacity to withstand risks, promotion of agricultural scientific and technological progress, and facilitation of international trade and investment. There are differences in natural resources, climate conditions and agricultural technology among countries, and international cooperation can realize complementary advantages and improve the productivity of global agricultural output. Through the "One Belt, One Road" initiative, China has developed agricultural cooperation with countries along its routes, promoting the sharing of agricultural technology and equipment and boosting regional agricultural development. In Africa, China has carried out South-South cooperation with Nigeria and other countries, and through technical assistance and agricultural demonstration projects, it has significantly improved local food production and agricultural technology. International agricultural cooperation helps countries to jointly resist risks and reduce the pressure faced by a single country. In the face of food crises, epidemics and other emergencies, international cooperation enables countries to support each other and work together to meet challenges. For example, China, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), has sent agricultural experts to developing countries to provide technical support and pilot projects through the "FAO+China+Host Country" model of tripartite cooperation, which has effectively enhanced the risk-resistant capacity of recipient countries. In addition, China and ASEAN countries have strengthened agricultural cooperation during epidemics to jointly ensure food security. International agricultural cooperation has also promoted progress in agricultural science and technology and enhanced global agricultural productivity. Through exchanges and cooperation, countries have shared advanced agricultural technology, management experience and development concepts. For instance, China’s advancements in agricultural science and technology have been extended to countries participating in the Belt and Road Initiative, fostering innovation in agricultural practices and supporting sustainable development. Simultaneously, China and African countries have achieved remarkable results in agricultural technology cooperation, through the establishment of agricultural technology demonstration centers, and the promotion of local agricultural technology and planting models. In terms of promoting international trade and investment, international agricultural cooperation has lowered trade barriers and optimized the layout of the agricultural industry chain. For example, China and countries along the "Belt and Road" have signed agricultural cooperation agreements to facilitate trade and investment in agricultural products. Data show that China has signed agricultural cooperation agreements with more than 80 countries and carried out more than 650 agricultural investment projects. In addition, China has deepened agricultural cooperation with ASEAN countries, further expanding the market for agricultural products through the establishment of free trade zones and agricultural cooperation platforms. China's agricultural cooperation projects with Laos have significantly boosted local agricultural productivity through the establishment of agricultural science and technology demonstration parks and the promotion of high-yield planting techniques. In addition, China's cooperation with Thailand in the field of agriculture has also achieved remarkable results, promoting the optimization and upgrading of the agricultural industry chain of both sides through technical exchanges and trade cooperation.

3.2. Priorities of Agricultural Transformation in PRC

As agriculture is a fundamental industry of the national economy, China has made significant contributions to its development. However, with rapid social and economic progress, the agricultural sector has undergone profound changes, placing it at a critical transition period from traditional to modern practices. The internationalization of agriculture is an inevitable path toward China's agricultural modernization.

Facing resource and environmental constraints, shifts in labor structure, and pressure from international competition, China's agricultural transformation can be summarized in two key aspects:

– first, the shift from a traditional production model to one that prioritizes technological innovation, sustainable development, and modern business practices;

– second, the transition from a domestic food security focus to deeper integration into the global market.

The transformation of Chinese agriculture is deeply rooted in its rich historical context and has been driven by major economic and social changes. In recent decades, China's agricultural sector has experienced a significant transformation, shifting from traditional farming practices to more modern, industrialized methods. This change has been driven by several factors, including policy reforms, technological advancements, and the increasing need to ensure food security amidst population growth. To understand the current state of China's agricultural industry, it is essential to explore its historical context and the economic and social factors that have shaped its development.

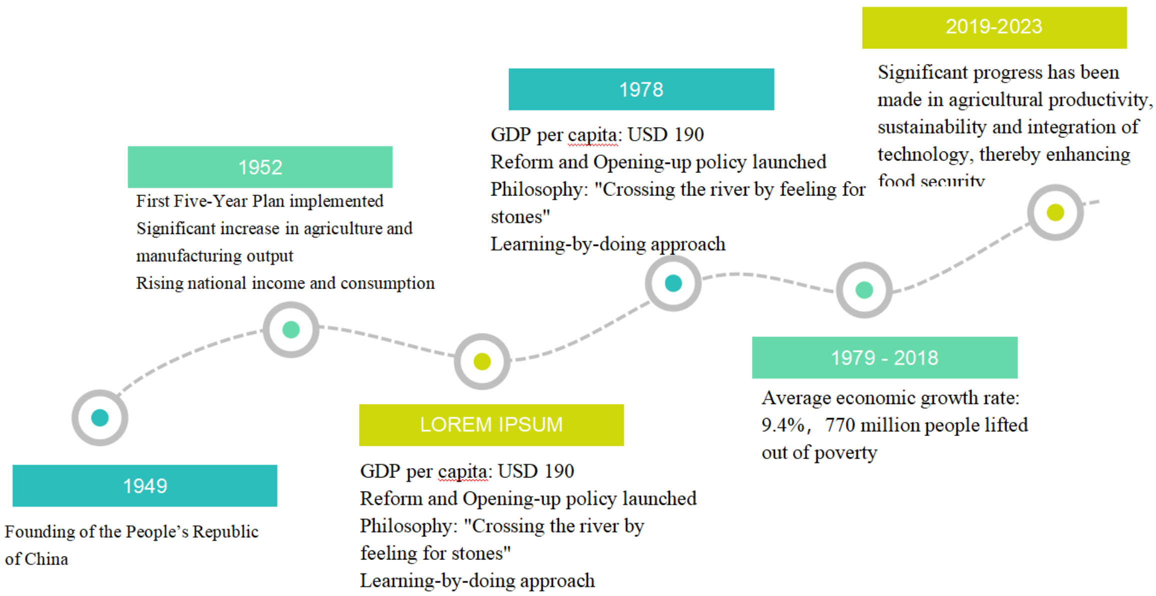


Fig. 3.5. Four key periods of China's agricultural transformation

Source: systematized by the author

As depicted in Figure 3.5, China's agricultural transformation has unfolded in four distinct phases: the period from 1949 to 1978 marked by restoration and collectivization, where land reforms and agricultural collectivization established the foundation for a socialist agricultural system; from 1978 to 2018, a phase of reform, opening up, and marketization, during which the household contract responsibility system and market-driven reforms greatly enhanced agricultural productivity and economic vitality; from 2019 to 2023, a period focused on modernization and sustainable development, where scientific advancements, green development, precision agriculture, and eco-agriculture became central, steering agriculture towards high quality and sustainability. These transformations not only fueled the rapid growth of Chinese agriculture but also provided valuable insights for global agricultural sustainability.

In recent years, China has made significant strides in the transformation and upgrading of its agricultural sector. Regarding scientific and technological collaboration and innovation, since the implementation of the 13th Five-Year Plan, the Ministry of Agriculture and Rural Affairs has enhanced its cooperation framework, utilizing joint laboratories, overseas agricultural research centers, and cooperative bases to facilitate the import and export of agricultural scientific and technological expertise, while also strengthening the adoption of advanced technologies. Notably, institutions such as the Chinese Academy of Agricultural Sciences and the Chinese Academy of Tropical Agricultural Sciences have successfully introduced a wide range of superior varieties in specialty grains, cotton, oil crops, fruits, vegetables, flowers, and livestock and aquaculture. This has significantly enriched the diversity of genetic resources in China’s agricultural sector. In terms of trade and market cooperation, China’s total agricultural imports and exports are projected to rise from USD 246.8 billion in 2020 to USD 307.46 billion in 2023, achieving a compound annual growth rate of 7.62% over three years. The import sector continues to expand, with agricultural imports reaching USD 234.19 billion in 2023, representing 14.3% of global agricultural imports. ranking first in the world for five consecutive years; in terms of exports, the scale of exports still maintains 73.27 billion U.S. dollars in a complex international economic and trade environment, maintaining the status of the world's fifth-largest exporter according to the SITC classification statistics. China has signed 19 FTAs with 26 countries and regions around the world, and the degree of agricultural market opening has reached more than 90%. In terms of outbound investment and cooperation, by the end of 2023, China's stock of outbound direct investment in agriculture will reach US$38.65 billion, up 28% from 2020. The number of enterprises established abroad has reached 1010, covering 108 countries and regions. The flow of agricultural investment in "Belt and Road" countries amounted to 1.46 billion U.S. dollars, accounting for 80.2% of total agricultural outbound investment; the stock exceeded 32 billion U.S. dollars, focusing on the layout of Southeast Asia (accounting for 42%), Africa (accounting for 28%) and Central Asia (accounting for 15%). The total investment in the third phase of the China-FAO South-South Cooperation Program (2022-2025) has increased to 120 million U.S. dollars, and agricultural technology demonstration projects have been implemented in 37 countries, with a cumulative total of more than 20,000 times of training for local technicians.

The focus of China's agricultural transformation should be made on five major areas (Fig. 3.6), namely:

1. Agricultural science and technology innovation,
2. Sustainable agricultural development models,
3. Agricultural financial support,
4. Rural land reform and agricultural business model innovation,
5. Upgrading of the agricultural industry chain.

1. Science, technology and innovation in agriculture: enhancing production efficiency. Agricultural science and technology innovation is an important driving force for enhancing agricultural productivity, guaranteeing food security and promoting agricultural modernization. Smart agriculture, genetic improvement and precision agriculture technologies are key to enhancing agricultural productivity [233].

Smart agriculture is the use of the Internet of Things, big data, artificial intelligence and other technologies, real-time monitoring and precise control, which optimizes the agricultural production process, improves the efficiency of the use of agricultural resources and reduces waste [133].

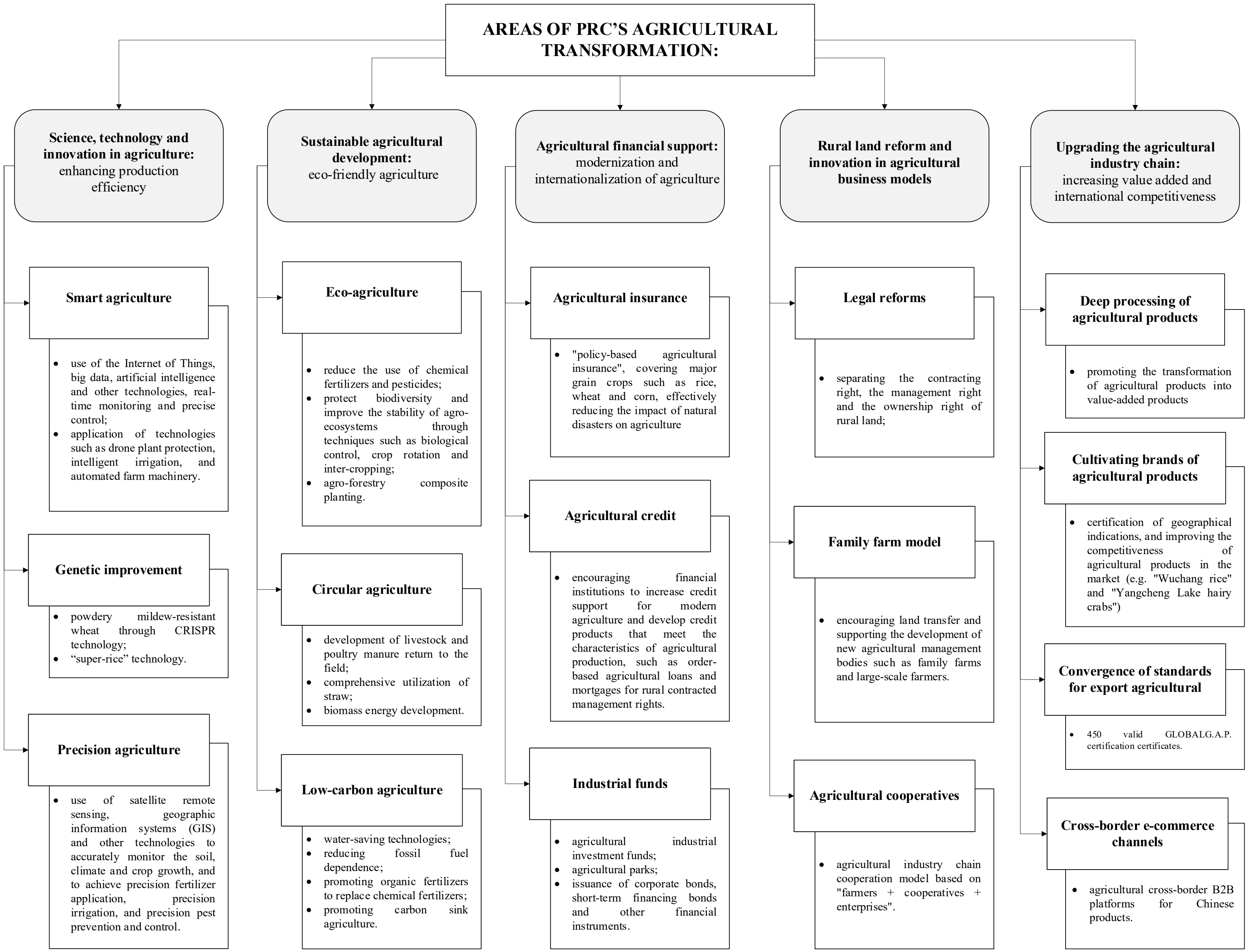


Fig. 3.6. Areas of China's agricultural transformation

For instance, the adoption of technologies like drone-based pest control, smart irrigation systems, and automated farming equipment has notably enhanced agricultural productivity and resource efficiency. The use of UAV technology for plant protection has considerably increased the efficiency and effectiveness of pest management in agricultural operations [60]. China installed 2.2 million Beidou terminal farm machines in 2023, with operational efficiency and operational precision reaching international advanced levels, and the total number of plant protection drones was nearly 200,000, with an annual operational area exceeding 2.1 billion mu. Intelligent irrigation system realizes precise irrigation and reduces water waste through real-time monitoring of soil moisture and meteorological data 2023, China's intelligent irrigation technology has been promoted in several provinces, effectively improving the efficiency of water use.

Genetic improvement is the use of biotechnology to cultivate high-yielding, disease-resistant and drought-resistant varieties to increase agricultural yields and minimize the influence of agricultural production on the environment. For example, China's "super rice" technology has been popularized in many provinces, significantly increasing the level of rice yields. In 2023, the Chinese Academy of Agricultural Sciences (CAAS) bred powdery mildew-resistant wheat through CRISPR technology, which not only leads to a reduction in pesticide application, but also considerably enhances the yield per acre. The successful application of this technology has provided new ideas for solving the problem of food security. China's "super rice" technology has been popularized in many provinces, significantly increasing the level of rice yields. In 2023, the average yield of super rice reached more than 700 kilograms per mu, making an important contribution to ensuring national food security.

Precision agriculture involves utilizing technologies such as satellite remote sensing and geographic information systems (GIS) to monitor soil conditions, climate, and crop growth with high accuracy. This enables precise applications of fertilizers, irrigation, and pest control, thereby enhancing the management of agricultural production. In 2023, China employed satellite remote sensing technology to comprehensively monitor key grain-producing regions, providing a scientific foundation for precise fertilizer application, pest control, and other agricultural practices [157]. The use of GIS technology in agriculture has enabled detailed management of farmland. In 2023, China expanded the application of GIS technology across several provinces, leading to notable improvements in agricultural production efficiency through accurate fertilization and irrigation practices.

Through the application of these technologies, China has not only improved the efficiency of agricultural production and resource utilization, but has also provided strong support for guaranteeing national food security and promoting agricultural modernization. In the future, China should continue to intensify its efforts in research and development and the promotion of these technologies, so as to further enhance the international competitiveness and sustainable development capacity of agriculture.

2. Sustainable agricultural development: eco-friendly agriculture. Against the backdrop of increasingly prominent resource and environmental constraints, China's agriculture is developing in the direction of green, low-carbon and sustainable development, and eco-agriculture, recycling agriculture and low-carbon agricultural technologies have become the key to enhancing agricultural productivity.

Eco-agriculture aims to minimize the utilization of chemical fertilizers and pesticides, safeguard biodiversity and enhance the stability of agro-ecosystems by means of techniques like biological control, crop rotation, inter-cropping and agro-forestry complex planting. For example, biological control technology effectively controls pests and diseases and reduces the use of pesticides through the introduction of natural enemies of pests. For example, intelligent eco-agriculture realizes intelligent perception and precise management within the domains of agricultural production, rural ecology and farmers' life through intelligent monitoring systems [178].

Circular agriculture refers to the resource utilization of agricultural wastes, like the development of returning livestock and poultry manure to the fields, the comprehensive utilization of straw and the development of biomass energy, so as to achieve the synergetic development of agricultural production and environmental protection. For instance, the technology of straw return not only enhances soil fertility but also mitigates the environmental pollution resulting from straw burning. The material recycling and multi-level utilization technology used in eco-cycle agriculture gives full play to the maximum application value of resources, realizes the reuse of many kinds of wastes in agricultural production, improves the cleanliness of agricultural production, and creates a green, ecological and sustainable development model for agriculture [250].

Low-carbon agriculture involves the advancement of energy-saving and emission-reduction technologies, like lessening reliance on fossil fuels, advocating the use of organic fertilizers in place of chemical fertilizers, and promoting carbon sink agriculture, with the aim of lowering agricultural carbon emissions and enhancing the capacity of agriculture to deal with climate change. For instance, through the promotion of efficient water-saving techniques, the efficiency of agricultural water utilization is enhanced and energy consumption is reduced. For instance, through promoting efficient water-saving technologies, it enhances the efficiency of agricultural water utilization and lowers energy consumption. The Guiding Opinions on Accelerating the Comprehensive Green Transformation of Agricultural Development and Promoting Rural Ecological Revitalization suggest that by 2030, the efficiency of agricultural resource utilization will be significantly improved, the level of waste resource utilization will be raised, and a green, low-carbon and recycling agricultural industrial system will be initially constructed. Specific measures include promoting the reduced use of chemical fertilizers and pesticides, the promotion of green prevention and control technologies, and the development of water-saving agriculture and dry-crop agriculture [173].

3. Agricultural financial support: promoting the modernization and internationalization of agriculture. Agricultural financial support is an important guarantee for the modernization and internationalization of agriculture. Agricultural insurance, agricultural credit and industrial funds are key to promoting agricultural modernization and internationalization.

Agricultural insurance is crucial to the establishment of a sound agricultural insurance system in order to improve farmers' ability to resist risks. In recent years, China has vigorously promoted "policy-based agricultural insurance", covering major grain crops such as rice, wheat and corn, effectively reducing the impact of natural disasters on agriculture [153]. In 2023, the amount of insurance payouts under China's policy-based agricultural insurance amounted to 22 billion yuan, providing important economic support for affected farmers. The application of satellite remote sensing and other technologies has improved the efficiency and quality of agricultural insurance label checking and escorted smart agriculture.

Agricultural credit helps alleviate agricultural financing difficulties by encouraging financial institutions to increase credit support for modern agriculture and develop credit products that meet the characteristics of agricultural production, such as order-based agricultural loans and mortgages for rural contracted management rights [204]. By the end of April 2023, the balance of agriculture-related loans in China reached RMB 53.16 trillion, with a year-on-year growth of 16.4%. Simultaneously, banks have provided the necessary financial security for agricultural production by optimizing product innovation, promoting the modernization of agriculture.

Industrial funds support the development of modern agricultural parks and agricultural leading enterprises by setting up agricultural industrial investment funds, and advance the research and development of agricultural science and technology as well as the upgrading of agricultural product processing industries. For instance, in 2023, China established several agricultural industry investment funds with an overall scale of 50 billion yuan, providing support for the development of a number of modern agricultural parks and leading agricultural enterprises. Additionally, the financing channels for agricultural enterprises have been expanded by means of the issuance of corporate bonds, short-term financing bonds and other financial instruments.

Through measures such as agricultural insurance, agricultural credit and industrial funds, China has not only improved the risk-resistant capacity of agriculture, but also offered robust financial backing for the modernization and internationalization of agriculture. In the future, China should continue to improve its agricultural financial system, enhance financial assistance for agriculture and advance high-quality agricultural development.

4. Rural land reform and innovation in agricultural business models. Reform of the land system and innovation in the agricultural business model are important measures to promote the modernization of Chinese agriculture. In recent years, China has kept on enhancing the system of separating the three rights related to contracted land, separating the contracting right, the management right and the ownership right of rural land, realizing the optimal allocation of land resources, and ensuring that the relationship between the contracted land and the contracted land is stable and unchanged for a long time. Specifically, land ownership is vested in the collective, contracting rights are vested in farmers, and management rights can be transferred [36]. The core of this system is to safeguard farmers' rights and interests in land contracting, while Simultaneously stimulating the vitality of the land and improving its utilization rate. In recent years, the Chinese Government has placed significant emphasis on the reform of the rural land system and has promulgated a series of policies and regulations to offer robust safeguards for the implementation of the "three rights" system. For example, the Rural Land Contracting Law and the Measures for the Administration of the Transfer of Contracted Rural Land Management Rights. Land transfer service centers have been set up to build land transfer trading platforms and provide services such as policy consultation, contract authentication and dispute mediation. Through land transfer, large-scale agricultural operations have been able to develop rapidly, and common agricultural business models include family farms, agricultural cooperatives and entrepreneurial business models.

The family farm model encourages moderate-scale operations and enhances the efficiency of agricultural production. Through policy support, the State encourages land transfer and supports the development of new agricultural management bodies such as family farms and large-scale farmers [65]. As of the end of 2023, the overall quantity of family farms across the country had amounted to 4.2 million, and the average operational scale was 156.8 mu.

Through the integration of resources, agricultural cooperatives are able to realize large-scale production and improve market competitiveness. At present, China has formed an agricultural industry chain cooperation model based on "farmers + cooperatives + enterprises" [57]. By the end of 2023, there were 2,456,000 farmers' cooperatives registered in accordance with the law, driving nearly half of the country's farming households. Of these, 815,000 were in poverty-stricken areas, absorbing 7.28 million households.

The entrepreneurial business model encourages leading agricultural enterprises to develop modern agricultural industry chains and promote the industrialization of agriculture. Through business models such as "company + farmer" or "order farming", they have increased the added value of agriculture [165]. At present, the number of agricultural industrialization leading enterprises at the county level or above has increased to 98,000, leading the creation of more than 8,500 consortiums, and driving 19.2 million farming households by radiation.

By means of the reform of the land system and the innovation in the agricultural business model, Chinese agriculture is gradually being modernized. The development of family farms, agricultural cooperatives and entrepreneurial business models have not only enhanced the efficiency of agricultural production, but also strengthened the competitiveness of agriculture in the marketplace, laying a solid basis for sustainable agricultural development.

5.Upgrading the agricultural industry chain: increasing value added and international competitiveness. Traditional agriculture is dominated by the production of primary agricultural products, with low added value and insufficient competitiveness. Upgrading the agricultural industry chain is an important direction for improving agricultural economic efficiency. By means of deep processing, branding, the creation of high value-added products, the convergence of standards for export agricultural products, and the expansion of cross-border e-commerce channels, the upgrading of China's agricultural industry chain has not only raised the added value of agricultural products, but also strengthened the international competitiveness of agriculture.

Promoting the in-depth processing of agricultural products like grains, fruits and vegetables, livestock and poultry, and raising the added value of agricultural products. In recent years, the in-depth processing of agricultural products has witnessed rapid development in China, effectively facilitating the transformation of agricultural products into value-added ones. For instance, the Notice on Several Policies and Measures for Promoting the High-Quality Development of the In-depth Processing of Agricultural Products issued by the Ministry of Agriculture and Rural Affairs and 15 other departments indicates that the in-depth processing of agricultural products is a crucial link in extending the agricultural industry chain, enhancing the value chain, optimizing the supply chain, and establishing a benefit chain. It is also an important supporting force in promoting the supply-side structural reform of agriculture and accelerating the modernization of agriculture and rural areas.

Fostering brands of agricultural products with Chinese characteristics, advancing the certification of geographical indications, and enhancing the competitiveness of agricultural products in the market. For instance, "Wuchang rice" and "Yangcheng Lake hairy crabs" have turned into high-end agricultural product brands. Researches have indicated that strengthening the competitiveness of geographical indication agricultural product brands not only fulfills the growing consumer demands of domestic consumers, but also boosts the international competitiveness of China's agricultural products [248].

Promote the growth of organic agriculture, specialized agriculture and functional foods to enhance the market value of agricultural products and expand international markets [89]. For example, through the refinement of agricultural production inputs, processes and outputs, fine agriculture expands the agricultural industry chain, enhances the value chain and improves the benefit chain, effectively promoting the "three-chain coupling" of the agricultural industry chain, value chain and benefit chain.

The convergence of standards for agricultural products for export is an important means to boost the international competitiveness of agricultural products. The GLOBAL G.A.P. certification system is an internationally recognized certification standard for agricultural products that aims at guaranteeing the safe production and sustainable development of agricultural products [123]. As of the end of 2019, China has 450 valid GLOBALG.A.P. certification certificates. These certifications not only enhance the international recognition of agricultural products, but also help farmers gain more export opportunities. For example, McDonald's has required its global suppliers of primary agricultural products to be progressively GLOBALG.A.P. certified since 2020, which has provided certified farmers with a stable market channel.

The expansion of cross-border e-commerce channels has offered a new platform for agricultural exports. The transaction value of agricultural cross-border B2B platforms has increased by 40% annually, showing strong growth. These platforms not only help farmers and enterprises expand into international markets, but also enhance the added value of agricultural products [61]. For example, through cross-border e-commerce platforms, Chinese specialty agricultural products such as Anxi Tieguan tea, Yunnan wild mushrooms and Shanxi Luochuan apples have been able to enter the international market and enhance the international visibility of Chinese agricultural products.

In general, the internationalization of China's agriculture has its own specifics and a few conditions for implementation should be taken into consideration:

– the degree of openness of China's market for agricultural products;

– the structure of dominant commodities;

– the regional patterns of internationalization of agriculture;

– the pattern of the agricultural internationalized market access;

– internationalization of agricultural business methods;

– internationalization of agricultural capital;

– internationalization of agricultural technology.

The key point of the internationalization of agricultural products lies in achieving the international standard of agricultural products. The standardization of agricultural products not only offers the quality and regulatory foundation for the production of agricultural products, but more significantly, through the standardization of agricultural products, the competitiveness of agricultural products in the international market can be enhanced, which is the basic condition for the creation of brand names of agricultural products. Standardization of agricultural products must be international and should be consistent with the content of international standards. Standardization of agricultural products must take into account the international food, food safety standards, must refer to the international community's popular food structure, the structure of health elements, food taste, must comply with the dietary culture of importing countries. For example, China has a competitive price advantage in the international market of agricultural products such as pork, poultry, aquatic products, vegetables, fruits, flowers, etc. However, if the quality and health standards of these agricultural products fail to meet the requirements of international standards, such as more epidemics, higher chemical fertilizer and pesticide residues, the export of agricultural products having comparative advantages will be severely impacted.

The internationalization of agriculture and the import and export of agricultural products is an inevitable trend. From the world as a whole, the dependence of the world food trade is increasing trend, in 1995 compared with 1960, food export dependence from 9.2% rose to 14.1%, food import dependence from 8.7% rose to 13.6%, China's food export dependence since 1988 to 1995, an average of 1.9% in 8 years, import dependence in 8 years, an average of 3.1%, the highest dependence year is 1995, the year of the import The highest dependence was 4.4% in 1995 and the lowest was 1.6% in 1993, while the highest export dependence was 3.0% in 1993 and the lowest was 0.2% in 1995. There is no international standard for the appropriate level of food trade dependence on imports and exports, and Chinese scholars have different views on this issue, with one advocating that import dependence should be controlled at less than 5 per cent and the other at less than 10 per cent. We believe that, in the case of ensuring basic food self-sufficiency, it is more appropriate to control the dependence on food imports to within 10 per cent, because China's geographical space is large, and the transportation of grain from the north to the south is not as economically advantageous as the transportation of grain from the south to the north, and expanding the dependence on imports on the basis of increasing the dependence on exports is not risky to food security, and can more effectively allocate resources according to comparative advantage and improve the efficiency of resource utilization.

In line with the fundamental trend of agricultural development in the present world, the agricultural structure should be brought into line with international agriculture, and emphasis should be placed on the development of animal husbandry and the agricultural product processing industry. In terms of the agricultural structure, the output value of animal husbandry ought to surpass that of planting, and the output value of the agricultural product processing industry should amount to 3-4 times the agricultural output value. Guided by the global market, based on the comparative advantages of agriculture, relying on scientific and technological advancement, enhancing the variety and quality of agricultural products, and facilitating the optimization and upgrading of the agricultural structure. The internationalization of China's agricultural economic structure should be based on the basic premise of national conditions. For agricultural products that lack comparative advantages, such as grain, vegetable oil, cotton and other bulk crops that are characterized by land density, under the basic condition of guaranteeing a safe supply, China's production can be moderately reduced, and the resources of the international agricultural market can be actively and effectively utilized to adjust the gap between supply and demand. For agricultural products that possess comparative advantages, like livestock and poultry, aquatic products, vegetables, fruits, tobacco, and related processed goods, active measures need to be adopted to further leverage the comparative advantages, give priority to the development of these agricultural industries, enhance external competitiveness and increase the share in the international market. In the process of realizing the internationalization of the agricultural structure, the following principles must be adhered to: adjusting the structure of agricultural production oriented to the international market; adjusting the structure of agricultural industry oriented to high technology; adjusting the structure of agricultural product processing oriented to high value-addedness; adjusting the structure of the agricultural regional economy oriented to the characteristics of products; and adjusting the structure of the agricultural development strategy oriented to the development trend of the world's agricultural economy[146].

Due to the differences in production conditions and productivity levels, China's grain crops have relatively high production costs, while cash crops have relatively low production costs. Taking wheat and cotton as examples, the import price of wheat is higher than that of China by 36.0%, and that of cotton is higher than that of China by 40%, so China's cash crop agricultural products have a comparative advantage. Comparison of food and livestock products and processed products, processed products, livestock products have a comparative advantage, to pork, corn, canned pork, for example, corn export prices higher than China's 4.1%, pork higher than China's 14.2%, canned pork higher than China's 28.6%, so China should vigorously develop the processing industry of agricultural products and animal husbandry, and gradually realize the upgrading of products and extend the industrial chain. In terms of planting industry, corn import price is 93.3% higher than China's price, rice is 53.5% higher than China's price, soybean is 26.9% higher than China's price, wheat is 36.0% higher than China's price, the most comparative advantage is corn and rice, followed by wheat and soybean. Considering that China's 1.4 billion people must eat based on China, in order to ensure the supply of basic foodstuffs, China should learn from Japan's experience, separating the basic foodstuffs of rice and wheat from other agricultural products, and implementing high-price protection of rice and wheat, adopting quotas and licenses to restrict their import and export, and regulating other agricultural products through tariffs, and implementing liberalized trade.

China is a vast nation, where there are significant disparities in the structure of resource endowments, labor, capital and technology in each region, which makes the input-output benefits of different varieties in each region very different, and each region has its own advantages, and the pattern of agricultural internationalization should have regional characteristics [241]. The eastern region in ensuring the necessary food, especially rice production, based on its location, capital and technological advantages, can consider learning from the experience of the Netherlands, Israel, the implementation of imported corn, the use of low labor cost advantages, vigorously develop animal husbandry, export of high price-added meat products and agricultural by-products processed products; Central China's commodity grain is more concentrated production areas, with grain production advantages, especially the northeast region, a large number of overcrowding in corn. Especially in the northeastern region, a large surplus of corn, we can consider learning from the experience of the United States, and actively participate in the Northeast Asian Economic Circle of international cooperation, vigorously export corn; western region to ensure the development of food production Simultaneously, we can consider learning from the experience of Israel, to focus on the development of cash crops, especially the advantages of the obvious tropical, subtropical cash crops, famous products, such as Guizhou's tung oil, black glutinous rice, Yunnan's Guizhou's tung oil, black glutinous rice, Yunnan's roasted cigarettes, and Xinjiang's melons and fruits, etc., to participate in the international economic cycle, and to import food from Thailand, Vietnam, and other countries as appropriate to supplement the shortfall in the region [135].

Market access issues in the internationalization of agriculture. The internationalization of China's agricultural market is one of the main criteria for the internationalization of the agricultural economy. Its main meaning is twofold: first, the operation and management rules of China's agricultural market should follow international practice and be in line with those of the international agricultural market; second, China's agricultural market should be gradually opened up to the outside world, and a certain number of foreign agricultural commodities should be allowed to enter China's market under the principle of fairness and reciprocity in order to satisfy the needs of enterprise production and social consumption. The benefits of the internationalization of the agricultural market are twofold: firstly, a considerable amount of foreign high-quality agricultural imports can play a role in regulating the supply and demand in China's agricultural market and curbing price fluctuations in China's agricultural market. Secondly, the internationalization of China's agricultural market can also enable Chinese agricultural enterprises to undergo international competition in China's market when they are not out of the country, to participate in the process of globalization of the agricultural economy, and to create the conditions for entering the international market and international competition in the future. However, in the process of internationalization of China's agricultural market, developing countries should take a moderate approach to the entry of foreign commodities into the Chinese market. According to the practical experience of the internationalization of China's agricultural market, the share of imported agricultural products in China's market should be maintained at about 20%. The most basic principle is that foreign trade should maintain a balance of income and expenditure. Both the protection of Chinese agriculture and farmers, to prevent the impact of foreign agricultural products, to ensure that the basic food self-sufficiency, but also to make full use of the international market and international resources, should be based on different situations to choose the way of internationalization of agricultural market access. Multilateral agreements. China's accession to the World Trade Organization (WTO), and all countries in the world to reach a multilateral trade agreements, in compliance with the premise of multilateral agreements, China can strengthen the "gray area" activities, make full use of a variety of "exceptions to the terms" to expand and protect their interests. Bilateral agreements. Drawing on Japan's experience in establishing a rice production base in Thailand, China should fully consider utilizing the land resources and excess agricultural production capacity of neighboring countries and developed countries to make up for China's lack of agricultural resources, and set up production bases for feedstuffs and industrial foodstuffs outside China through bilateral agreements. Construct regional economic circles and carry out agricultural cooperation within regional economic circles. First, to build the Northeast Asian Economic Circle. Taking the UN's Northeast Asia Tumen River Delta Development Plan as a blueprint, it includes northeastern China, Japan, South Korea, and the Far East of Russia, as well as North Korea and the People's Republic of Mongolia. Within this economic circle, corn and livestock products from northeastern China can be flowed to neighboring South Korea and Japan, and advanced agricultural technology from South Korea and Japan can be introduced to China, and consideration can be given to setting up a base for feed and industrial grain in the Far East of Russia; two. Build southwest China, Myanmar, Thailand, Vietnam and neighboring countries economic circle, in this economic circle, the shortage of food in southwestern China can be provided by Thailand, Vietnam; third is to build, including Taiwan, Hong Kong, Macao, mainland China's "China Economic Circle", China through the import of feed, take advantage of the low cost of labor, vigorously develop the China, by importing feed and taking advantage of low labor costs, will vigorously develop the livestock industry and the processing of agricultural and sideline products, and export high value-added livestock products and processed products to Macao and Hong Kong.

The connotations of the internationalization of agricultural business methods are: first, autonomous agricultural enterprises as the mainstay. In accordance with the popular methods of countries around the world, modern farms, agricultural groups and agricultural cooperative organizations with full autonomy and large-scale production and operation should be established rapidly. In the international agricultural market operation, pay attention to the market transactions between enterprises, business cooperation, enterprise and market connection. For example, in today's agri-food industry market, there are about 2 trillion dollars in global sales, and most of them are controlled by multinational corporations. This requires that in China has not yet become a corporate entity of millions of small farmers, through market competition, differentiation and combination, training a number of modern agricultural enterprises, so that it has the ability to operate the industrialization of agriculture and the ability to enter the international market competition. Secondly, take the market as the leader. In the operation of agricultural industrialization, the past has been the enterprise as the leader, that the market is basically equal to the demand, and the enterprise on the demand can be grasped, so hold the right to open up the market of the enterprise, will naturally become the leader. Too much emphasis on the leading role of enterprises, easy to ignore the core role of the market. From the point of view of today's developed countries' agricultural industrialization operation system, the market is the real leader. Firstly, the composition of agricultural industry is determined by the market; secondly, the operation of agricultural industry is operated according to the market situation; thirdly, all kinds of interests related to agricultural industry are also determined by the market exchange relationship. Therefore, in the process of internationalization of agricultural business methods, China must take the market as the leading role in the internationalization of agricultural business. The operation mode and behavior of agricultural internationalization should start from the market in order to occupy the Chinese market and develop the international market. Thirdly, entrepreneurs should be the backbone. In the past, the agricultural business is often seen things but not people, summarized "company + farmers", "cooperatives + farmers", "wholesale market + farmers" and other business models, it is difficult to operate in practice. In the industrialization of agriculture and internationalization of business, it is the living people, entrepreneurs who really play a role in general. With excellent entrepreneurs there are advantageous enterprises; with entrepreneurial groups there is division of labor and collaboration among enterprises; with international entrepreneurs there will be the internationalization of agricultural operations. Entrepreneurs are the soul and backbone of the industrialization and internationalization of agriculture, and they are the most excellent human resources. China is in the initial stage of industrialized agricultural management, so in the internationalization of agricultural management, we should emphasize the management mode of "market + entrepreneur + farmer".

The internationalization of agricultural capital is crucial to the modernization, industrialization and internationalization of China's agricultural economy. Foreign investment can, firstly, alleviate the contradiction of insufficient investment in agriculture; secondly, it can bring advanced agricultural production technology and marketing experience; thirdly, It can generate employment chances for the investment location and raise the income of farmers. fourthly, it can promote the adjustment of agricultural structure and improve the level of agriculture; in addition, foreign-invested agribusinesses can drive the export of agricultural products. However, the important precondition for the internationalization of agricultural capital is the flow of farmland property rights. Therefore, it is recommended that various possible and feasible forms of internationalization of agricultural capital should be explored as soon as possible, in order to accelerate the circulation of agricultural capital and enable international capital to occupy a certain proportion of agricultural capital.

China has become a major exporter of agricultural technology, providing solutions that help recipient countries improve sustainability. This includes everything from smart irrigation systems to drone technology to monitor crop health. In Kenya, for example, Chinese companies introduced solar-powered irrigation systems that reduced water use by 40% while increasing crop yields by 15% (Gao and Liu, 2020). Drone technology has also been widely adopted in countries such as Vietnam, where Chinese drones are being used to monitor rice paddies and apply fertilizers more accurately. Integrating these technologies into local agricultural systems can help increase efficiency and reduce environmental impacts, making agriculture in developing countries more sustainable. In addition to solar irrigation and drone technology, China has expanded its exports of precision farming tools and biotechnology innovations, which have had a significant impact on the sustainability of agriculture in developing countries. For example, in Ethiopia, Chinese companies have introduced precision agriculture systems that use sensors and satellite imagery to monitor soil moisture and help farmers optimize water use and avoid over-irrigation. These tools not only increase crop yields, but also reduce water use and minimize environmental stress on local ecosystems. By integrating these advanced technologies into their agricultural practices, recipient countries can address the challenges posed by climate change and resource scarcity and improve food security while reducing the environmental footprint of agriculture. In addition, China has played a key role in promoting biotechnology through the transfer of genetically modified seeds designed to withstand harsh environmental conditions. For example, in Southeast Asia, drought-resistant rice varieties developed in China have enabled farmers to maintain stable yield levels even when water is scarce (Li and Zhang, 2021). These biotechnology solutions not only increase resilience to climate change, but also reduce the need for chemical inputs such as fertilizers and pesticides, thereby reducing the environmental impact of agricultural activities. By sharing its expertise in agri-technology solutions, China is contributing to the long-term sustainability and productivity of agricultural systems in developing countries, ensuring that they are able to meet the growing food needs of their populations while conserving natural resources.

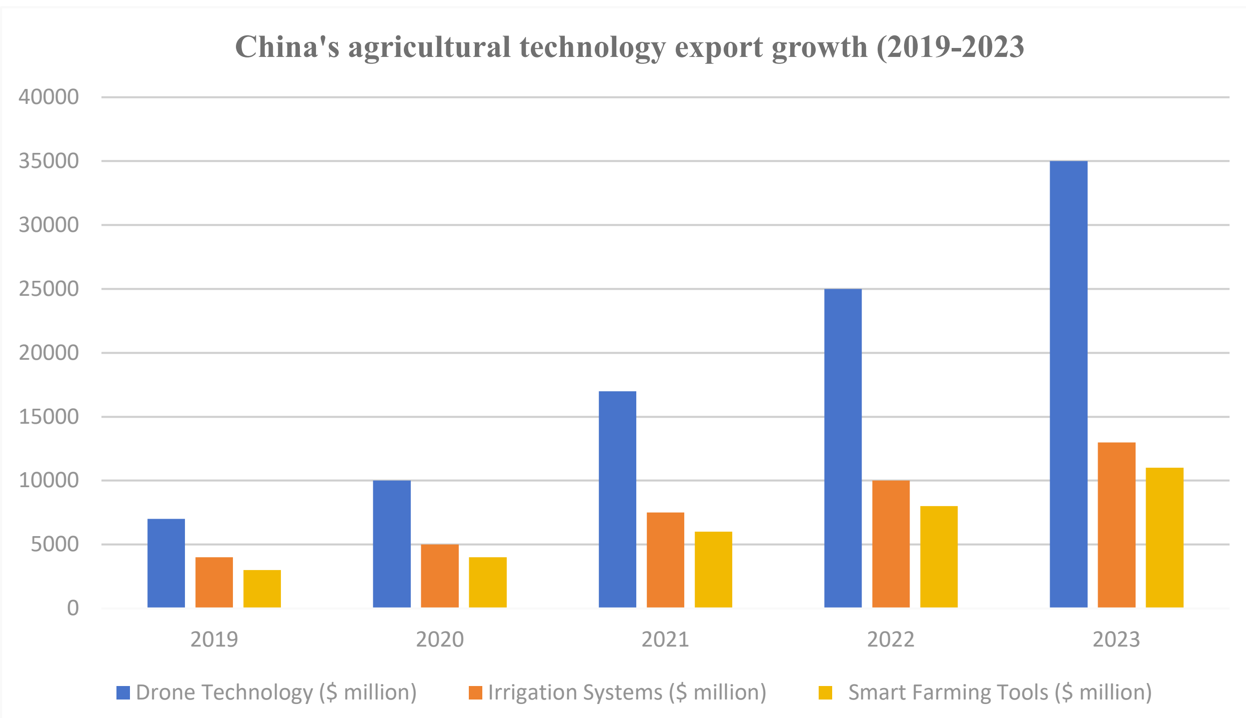


Fig. 3.7. Growth of Chinese Agri-Tech Exports (2019-2023)

Source: systematized by the author

As depicted in Figure 3.7, the growth of China's agricultural technology exports from 2019 to 2023 specifically centers on three key technologies: drone technology, irrigation systems, and smart agricultural tools. Exports of drone technology show a significant growth trend during this time period. in 2019, exports of drone technology amounted to approximately $5,000 million, while by 2023, this figure surges to more than $35,000 million, demonstrating China's rapid growth in the field of drone technology and its high level of acceptance in the international marketplace. Exports of irrigation systems also show steady growth. It grows from about USD 3,000 million in 2019 to about USD 12,000 million in 2023, reflecting China's innovations in efficient water-saving irrigation technologies and rising international competitiveness. The export value of smart agricultural tools, though relatively low, also shows a year-on-year growth trend. It grows from about US$2,000 million in 2019 to about US$9,000 million in 2023, indicating that China's technological advancement and market expansion in the field of intelligent agricultural equipment are gradually bearing fruit.

In summary, China's agricultural transformation is moving towards scientific and technological innovation, sustainable development, modernized operations, financial support and industrial upgrading. By deepening reform and driving innovation, Chinese agriculture is expected to achieve high-quality development, improve international competitiveness, guarantee national food security while promoting sustainable agricultural development.

3.3. Strategy of Chinese Agricultural Internationalization to Promote Sustainable Development and Food Security

Developing the internationalization of agriculture is necessary for China in many ways; it is not only an inevitable choice for upgrading the level of agricultural modernization, enhancing the overall competitiveness of the country's economy and guaranteeing food security, but also a key for promoting the income of farmers and the sustainable development of agriculture strategy.

The 'going out' strategy in agriculture represents a crucial pathway for China's agricultural sector to expand internationally. By adopting this approach, China's agriculture actively engages with the global economic framework, facilitating the flow of technology, capital, and resources. The execution of this strategy signifies the transition of China's agriculture from a conventional production model to a more modern and globally-oriented one. Through involvement in global agricultural governance and the establishment of cross-border agricultural value chains, China's agriculture has progressively evolved from merely 'going out' to effectively 'integrating in.' This shift achieves a two-way dynamic, transitioning from resource reliance to technology exportation and from product trading to participating in rule formulation.

The Table 3.4 shows the background of the formulation of China's agricultural "going out" strategy is mainly based on the joint drive of multiple factors at home and abroad, reflecting China's strategic considerations on national food security, optimal resource allocation, economic structure adjustment and international cooperation in the context of globalization.

The implementation mechanism of China's ‘going global’ strategy in agriculture is a multi-dimensional systematic project, the core of which is to promote the international development of agriculture through various means. This mechanism covers foreign direct investment (FDI), bilateral agreements, support for agricultural enterprises, technology transfer, infrastructure construction, finance and policy incentives, and other aspects. Based on relevant policy documents and practical cases, its implementation mechanism can be summarized into the following six core modules (Table 3.5).

The execution of China's "going global" strategy in agriculture aims to enhance the international competitiveness and influence of China's agriculture through multilateral cooperation, technology transfer, investment and other means, and advance the rational distribution and sustainable utilization of global agricultural resources. Carrying out this strategy not only contributes to safeguarding China's food security, but also contributes positively to global agricultural development and food security [126]. In the global agricultural governance system, multilateral institutions, national strategies and market forces form a complex network. China's agricultural ‘going global’ strategy and cooperation with international organizations have further promoted the improvement and development of global agricultural governance.

Table 3.4

Key drivers of the 'going out' strategy

Factor	Analysis and description
Domestic resource constraints and sustainable development needs	Scarcity of cultivable land and water resources:The per capita arable land area is less than 40% of the global average, water resources are unevenly distributed, pollution is aggravated, and the traditional agricultural model cannot meet domestic needs
	Environmental pressure: Long-term reliance on fertilizers and pesticides has led to soil degradation and ecological imbalance, and green agricultural technology needs to be explored.
	Rising labor costs: Urbanization accelerates the outflow of rural labor, and agricultural production costs increase, requiring industrial upgrading and overseas expansion.
Strategic needs to ensure national food security	Upgrading consumption structure: The growth of residents' income has led to an increase in demand for high-end agricultural products, such as soybeans, corn and other bulk agricultural products, which have a high degree of import dependence.
	Reducing supply chain risks: The instability of the global grain market and its influence of trade protectionism have intensified, and supply chain risks need to be dispersed through overseas layout.
	Reconstruction of the global supply chain: Invest in the entire overseas agricultural industry chain, including planting, processing, warehousing and logistics, to enhance international market influence.
Economic globalization and policy promotion	Competitive challenges after joining the WTO: China's agriculture faces the impact of agricultural subsidies from developed countries, and seeks breakthroughs through overseas investment.
	Support for the "Belt and Road" initiative: Agricultural cooperation is a key direction, promoting technology exports and demonstration farm construction, and strengthening international cooperation.
	Demand for capital and capacity output: Domestic agricultural technology and financial strength are enhanced, and enterprises are encouraged to optimize resource allocation through overseas investment.
Response to changes in the international agricultural landscape	Global land resource competition: Japan, South Korea and the Gulf countries have already laid out overseas farmland leasing in advance, and China needs to speed up the pursuit of high-quality agricultural resources.
	Technical standards and rule formulation: Take an active part in agricultural negotiations of FAO and WTO to advance the development of international trade rules in a fair direction.
	South-South cooperation and soft power enhancement: Strengthen economic and trade ties with developing countries through agricultural assistance and technical support.
Supporting strategies for domestic agricultural transformation and upgrading	Demand for industrial upgrading: Promote the transformation of agriculture from traditional models to high-value-added industrial chains, and enhance seed research and development and branding.
	Construction of a dual circulation pattern: Overseas agricultural investment can not only guarantee domestic food supply, but also promote the export of agricultural machinery, fertilizers and other industries, forming a complementary development model.

Source: systematized by the author

Table 3.5

Mechanism for implementing the ‘going out’ strategy in agriculture

Mechanism	Description
Foreign Direct Investment (FDI)	Chinese agribusinesses invest in overseas farmlands, processing plants, and distribution networks, particularly in Africa, Southeast Asia, and Latin America.
Bilateral Agreements	Trade agreements and partnerships with foreign governments facilitate agricultural cooperation, market access, and resource sharing.
Support for Agribusinesses	The Chinese government promotes and finances "dragon head enterprises," leading firms that integrate production, processing, and trade.
Technology Transfer	Introduction of advanced agricultural technology, mechanization, and modern farming techniques to increase productivity in overseas markets.
Infrastructure Development	Investment in roads, irrigation, and storage facilities abroad to support agricultural operations and enhance supply chain efficiency.
Financial and Policy Incentives	Preferential loans, subsidies, and tax benefits provided to enterprises expanding agricultural operations overseas.
Human Resource and Training Programs	Establishment of training centers and knowledge-sharing platforms to develop local talent and improve farming expertise.

Source: systematized by the author

For example, China's cooperation with the FAO has not only promoted the exchange and promotion of agricultural technology, but also strengthened coordination and cooperation in global agricultural governance. Furthermore, China's agricultural investment and collaborative initiatives in the nations along the Belt and Road have also provided strong support for local agricultural development and food security. Through these initiatives, China's agricultural 'going global' strategy is becoming more significant within the global agricultural governance framework, offering Chinese insights and solutions to promote global food security and sustainable agricultural development [31].

The internationalization of agriculture is an important driving force for the modernization of Chinese agriculture. Chinese agriculture is facing problems such as relatively backward technology, production efficiency to be improved, and increasing resource and environmental constraints. Through the internationalization of agriculture, China can import advanced agricultural technology and management practices from other countries, facilitating innovation in agricultural science and technology as well as industrial transformation. For example, the introduction of intelligent agricultural technology, gene improvement technology and Precision agricultural technology is capable of significantly enhancing the efficiency of agricultural production and the quality of agricultural products. Meanwhile internationalization can also promote the extension of the agricultural industry chain and the transformation from primary agricultural production to deep processing, branding and high value-added products, thereby facilitating the high-quality development of the agricultural economy. For example, the Netherlands has become a global agricultural powerhouse through scientific and technological leadership and institutional innovation, and its experience is worthy of China's reference.

The internationalization of agriculture helps to boost the international competitiveness of Chinese agriculture. In the context of globalization, competition in the agricultural market has become increasingly fierce. As a major agricultural country, the total value of imported and exported agricultural goods makes up a relatively small percentage of agricultural output, with an inconsistent level of internationalization. By engaging actively in international collaboration and division of labor, China can improve the allocation of agricultural resources and expand the global market presence of its agricultural products. Additionally, by driving supply-side structural reforms in agriculture, China can prioritize eco-friendly growth and strengthen its capacity for sustainable development [37]. For example, Via the "One Belt, One Road" initiative, China's agricultural cooperation with the countries along the route has not merely expanded the international market for agricultural products, but also facilitated the exchange and sharing of agricultural technology and experience, and enhanced China's agricultural position in the global industrial chain.

The internationalization of agriculture can help attract foreign investment and optimize resource allocation. Via the "One Belt, One Road" initiative, China's agricultural cooperation with the countries along the route has not merely expanded the international market for agricultural products, but also facilitated the exchange and sharing of agricultural technology and experience, and enhanced China's agricultural position in the global industrial chain. The main reason is that China's agricultural business environment has not yet been brought into line with international standards, and there is a lack of autonomous enterprises and a standardized market environment. By creating an internationalized agricultural business environment and attracting foreign direct investment, It is feasible to optimize the allocation of resources and boost the internationalization of the agricultural economy [149].

The internationalization of agriculture is conducive to coping with the problem of "too many people, too little land" in rural areas. Although China's rural areas are faced with the dilemma of "too many people, too little land", through the strategy of agricultural internationalization. It is capable of drawing upon the experience of nations like the Netherlands and Japan to advance the industrialization and internationalization of agriculture. Additionally, via the Belt and Road Initiative, China can collaborate on agriculture with countries along the route, integrate resources and enhance the comprehensive agricultural production capacity [111].

The internationalization of agriculture can promote farmers' income and rural economic development. By expanding the export of agricultural products and enhancing the added value of agricultural products, the internationalization of agriculture has broadened the channels for farmers to increase their incomes. Simultaneously, through the introduction of advanced international agricultural technology and management experience, it promotes the industrialization of agriculture and helps to alleviate the problem of slow growth in farmers' incomes.

The internationalization of agriculture is an important way to guarantee national food security. China is a vast country with a considerable population, and food security has all along been a significant foundation for national security. Through the internationalization of agriculture, China can make better use of international resources, optimize the sources of food imports and enhance the stability of food supply. For example, China currently imports soybeans mainly from Brazil, the United States, Argentina and other countries, and in the future, it can further expand its import channels, increase imports from Russia, Ukraine and other countries, and reduce its dependence on South America and the United States. Simultaneously, participation in international agricultural cooperation will also help enhance China's influence in global food governance and create a favorable international environment for guaranteeing national food security. Since 1979, China's hybrid rice technology has been introduced and cultivated in numerous countries and regions across Asia, Africa, and the Americas. Each year, it is planted on approximately 8 million hectares, yielding an average of about 2 tons per hectare more than local high-quality varieties. Chinese researchers have visited countries such as India, Pakistan, Vietnam, Myanmar, and Bangladesh to offer guidance and consultations. Furthermore, by means of international training programs, China has cultivated more than 14,000 experts and technicians specializing in hybrid rice from over 80 developing countries.

At present, the experience of foreign agricultural internationalization can be broadly divided into the following models:

1. The export-oriented model of excess resources represented by the United States. The United States has a highly developed agricultural system, and its agricultural internationalization service system is relatively complete. The United States expands its agricultural production capacity to the international market and strengthens its ability to allocate global agricultural resources through foreign aid, foreign agricultural investment, agricultural science and technology cooperation and participation in global agricultural organizations [11]. The United States agricultural resources, excess production capacity, with the production of grains, cotton, soybeans and other agricultural products of arable land resource advantages, choose labor-saving technology route, the development of grains, cotton, soybeans and other production projects with comparative advantages, through the development of "bilateral agreements, long-term agreements, processing and re-export programs, export promotion programs" to promote Grain, cotton, soybean exports, grain exports accounted for about 40% of the total production, accounting for about 20% of the international market volume of grain trading, cotton exports accounted

for more than 50% of the total production, accounting for 25% of the international market volume of cotton trading, soybean exports accounted for about 40% of the total production, accounting for about 70% of the international market volume of soybean trading. The United States focuses on agricultural diplomacy, enhancing its information-gathering function and promoting international cooperation in agriculture by setting up agricultural counselors and dispatching technical officials.

2. The agro-industrial integration model represented by Japan. Japan has realized the in-depth integration of agriculture and the agricultural product processing industry through the agro-industrial integration model. The commodity rate of agricultural products in Japan is as high as more than 95%, and the technology of food processing and deep processing of rice is at the leading level in the world. This model forward to undertake agricultural production, backward connection of agriculture-related services, through the deepening of the transformation and development of traditional agriculture to stimulate new vitality. Japan has built a model combining "industry, academia, research and enterprise", forming a structure in which the industry guarantees the quality of raw materials, the academia innovates scientific research results, the research community develops new products, and the enterprise community produces and sells the products, and carries out differentiated research and development and sales of agricultural products in a market-oriented manner, which facilitates the implementation of technological advancements and the conversion of research outcomes into practical applications [211].

3. The Netherlands is the representative of the outward-oriented model of resource conversion. The Netherlands, which is short of arable land and poor in resources, has capitalized on its strengths and avoided its shortcomings by giving full play to its technological advantages and vigorously developing its livestock and agricultural product processing industries for export through the procurement of cheap feedstuffs from all over the world [124]. Dutch agriculture is called "factory farming", 60% of the final products are sold abroad, 2/3 of which are processed. Secondly, the Dutch agricultural production is highly specialized and market-oriented, and its agricultural exports rank second in the

world after the United States. The Netherlands ranks first in the world in the export of flowers, fruits and vegetables, third in the world in the export of dairy products, third in the world in the export of animal and vegetable oils, and fourth in the world in the export of meat. In addition, the net agricultural exports of the Netherlands amount to more than 30 billion US dollars annually, and its greenhouse vegetables account for three-quarters of the total vegetable production, with 86% of the production going to the rest of the world. The export-oriented agriculture of the Netherlands is marked by value-added exports of processed agricultural goods. It involves a considerable number of imports of primary agricultural products for food processing and a significant amount of exports of high-value-added processed food items.

4. Israel represents a complementary model of insufficient resources. After the founding of the state of Israel had pursued the realization of self-sufficiency in agricultural and sideline products, but due to the constraints of natural conditions such as little arable land, infertile land and serious water shortage, food and other agricultural and sideline products have been imported in large quantities for a long period of time. after the 1970s, Israel has adjusted its agricultural policy, allocated agricultural resources according to its own natural conditions and resource endowment, and vigorously developed agricultural products with comparative advantages such as fruits, vegetables, flowers and other high-income Products. Through the export of these advantageous products, foreign exchange is earned and used to import agricultural products such as grains and sugar, thus realizing the efficient and sustainable development of agriculture [228].

The strategy of China's agricultural internationalization should take full account of China's national conditions and should not be simply copied from foreign models. The key parameters of such a strategy are highlighted in the Fig 3.8.

According to China's specific situation, China's agricultural internationalization should follow five objectives:

1. Ensuring of food security – to secure stable food supply chains through the diversified sourcing.

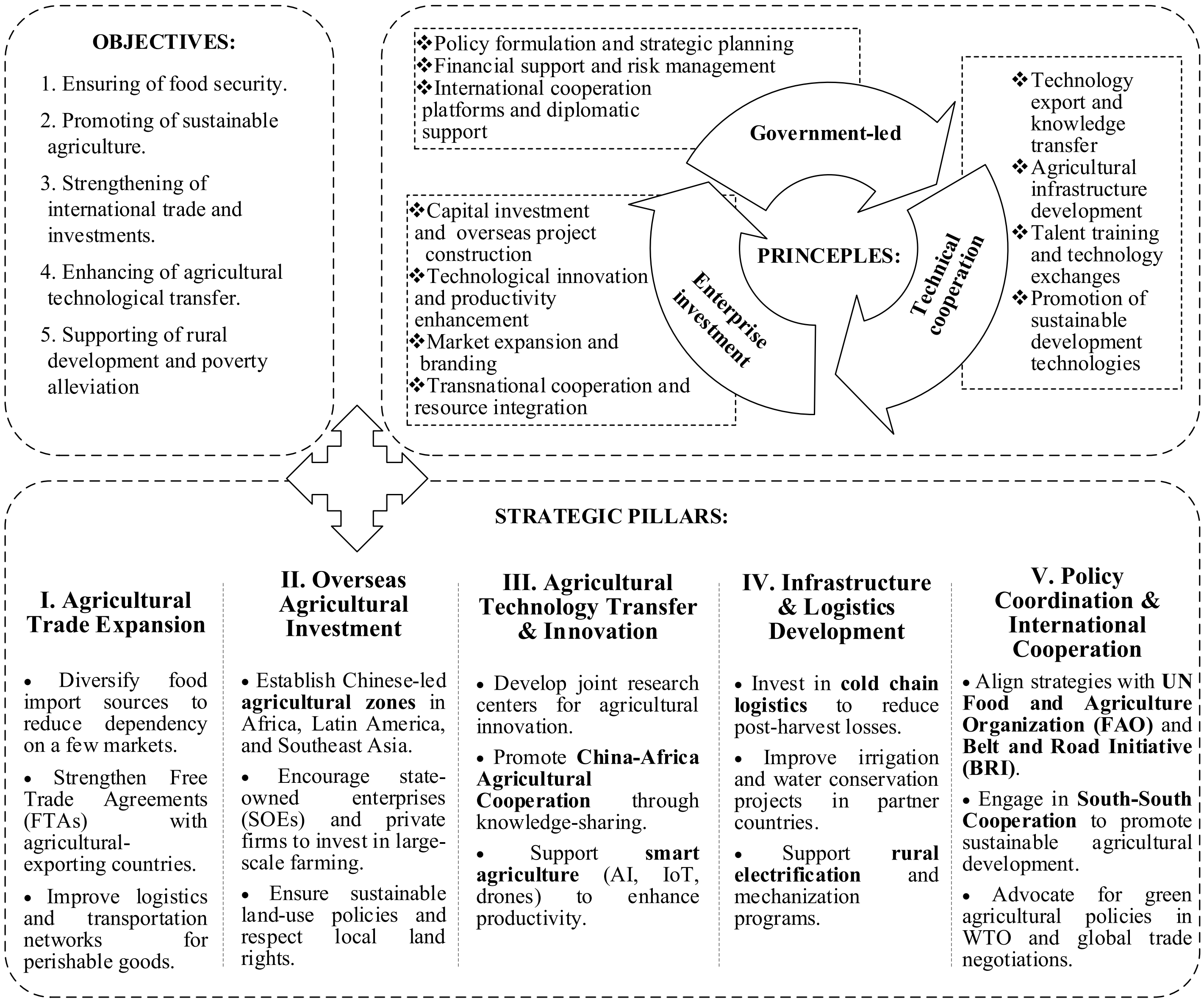


Fig. 3.8. Parameters of the Chinese strategy of agricultural internationalization

2. Promoting of sustainable agriculture – to develop eco-friendly and climate-resilient agricultural practices.

3. Strengthening of international trade and investment – to expand overseas agricultural cooperation and exports.

4. Enhancing of agricultural technological transfer – to share expertise with developing countries. Supporting of rural development and poverty alleviation – to create economic opportunities in partner countries.

The internationalization of Chinese agriculture must be balanced with food security to ensure that the problem of feeding the 1.4 billion people is solved. Although the allocation of agricultural resources is based on the principle of comparative advantage, it must be based on self-reliance and ensure the self-sufficiency of basic food rations. For example, by promoting high-yielding crop varieties and efficient agricultural technologies, China had significantly increased food production and ensured self-sufficiency in basic food rations.

The internationalization of agriculture should not only achieve the goal of a substantial increase in the production of agricultural products, but also the strategic goal of sustainable agricultural development and economic growth. We established the concept of sustainable development, set up an indicator system for sustainable development, and conduct a comprehensive assessment of the current situation and issues regarding sustainable development in agriculture. The notion of sustainable agricultural development has been extensively spread worldwide. However, because of the varying national circumstances and strengths of each country, there exist disparities in the comprehension of the concept of sustainable development. In developed countries, agriculture has been modernized, the agricultural economy is at a higher level, production capacity is stronger, and the function of agriculture has been expanded from the production of agricultural products to the beautification of the environment, health and nutrition, and food production is based on the goal of quality, with emphasis on the safety of food. Therefore, the sustainable development of agriculture in developed countries places greater emphasis on reducing resource consumption and protecting the internationalized environment.

The internationalization of Chinese agriculture should be carried out in accordance with the law of value, the law of supply and demand and the law of competition, in close conjunction with China's market and resource advantages, utilizing the international market and international resources, overcoming the backwardness of China's infrastructure, introducing advanced technology from abroad, Strengthening the comprehensive production capacity of agriculture and facilitating the upgrading and substitution of products, improving labor productivity, land productivity and product conversion rates, and increasing farmers' incomes.

The principle of "gradualism" in the promotion of agricultural internationalization should be maintained. As a large developing country undergoing institutional change and economic transformation, the pace of internationalization agriculture and opening up of can only be carried out in a planned and phased manner. By gradually expanding the opening-up, pilot projects will be carried out in some regions before being gradually extended to the whole country, to ensure the stable advancement of agricultural internationalization.

The Government ought to assume a significant role in the agricultural internationalization process by anticipating market trends, disseminating market supply and demand information, formulating and implementing policies and regulations on agricultural internationalization, and effectively guiding and regulating agricultural internationalization.

One of the major goals pursued by the internationalization of agriculture is to gradually improve the economic and social status of farmers and to narrow the income gap between urban and rural areas. In recent years, China's urban-rural income gap has tended to widen. In 2024, the per capita net income of rural residents amounted to RMB 16,740, though a detailed breakdown for cash income was not available. Nonetheless, the total income saw a year-on-year increase of 6.6%, reflecting a real growth rate of 6.3%.

Meanwhile, the per capita disposable income of urban residents nationwide in 2024 was RMB 41,183, representing a year-on-year rise of 4.5% (with an actual growth rate of 4.2%). The urban-to-rural income ratio in China for 2024 stood at 2.46:1, marking a decrease compared to the ratio in 2023. It is evident that the task of internationalizing China's agricultural economy remains arduous, yet the urban-rural income gap has shown improvement.

The process of agricultural internationalization cannot be separated from the cooperation and synergy of all parties, with government, enterprise and technology cooperation being the three key driving factors. China's agricultural internationalization strategy has formed a model of international cooperation in agriculture with Chinese characteristics through multi-level cooperation among government, enterprises and technology. The government plays a leading role in policy formulation and resource allocation, enterprises are the providers of capital and technology, and technical cooperation provides technical guarantee for agricultural internationalization. These three are interdependent and jointly promote the internationalization of Chinese agriculture.

1. Government-led. The government plays an irreplaceable role in promoting the internationalization of agriculture, which is manifested in the following aspects:

a. Policy formulation and strategic planning. Governments need to formulate policy frameworks and development strategies for the internationalization of agriculture, which should take into account the needs of the international market and the realities of Chinese agriculture. Through policy support, the government can provide agribusinesses with a roadmap for internationalization, such as promoting agricultural exports, simplifying trade procedures, and improving the investment environment.

b. Financial support and risk management. The financial assistance offered by the Government to agricultural enterprises, including tax exemptions, subsidy policies and export tax rebates, provides capital security for enterprises to expand into international markets. Furthermore, the government is also capable of lowering the potential risks for enterprises in overseas investment through risk compensation mechanisms to increase the attractiveness of investment.

c. International cooperation platforms and diplomatic support. The Government actively promotes the expansion of Chinese agribusiness in international markets through diplomatic channels and international organizations. By signing multilateral or bilateral agricultural agreements, the government is able to provide a more stable environment for international cooperation for Chinese agribusinesses and enhance the diversity and depth of agricultural cooperation through participation in global agricultural cooperation platforms.

2. Enterprise investment. As the implementation main body of agricultural internationalization, the investment behavior of enterprises is crucial to promoting international cooperation in agriculture, which is reflected in the following key areas:

a. Capital investment and overseas project construction. Agribusinesses promote overseas projects through capital investment, such as the establishment of farms and processing facilities, which provide the necessary conditions for realizing the integration of global agricultural supply chains. Corporate investment can help expand the international market share of Chinese agriculture and boost the international competitiveness of domestic agricultural products.

b. Technological innovation and productivity enhancement. Enterprises not only provide financial support, but also increase the efficiency of agricultural production by means of technological innovation. Technological innovations, such as smart agriculture, precision agriculture and gene-editing technologies, not only help enterprises to improve their own competitiveness, but also contribute to the improvement of agricultural productivity in international partner countries.

c. Market Expansion and Branding. Enterprises invest in building brand images in international markets, not only by exporting agricultural products, but also through conducting marketing activities to increase the added value of their products. Brand building by enterprises helps to expand market share and promote the visibility and influence of Chinese agriculture in the global market.

d. Transnational cooperation and resource integration. Agricultural enterprises establish strategic alliances with partners in other countries to share technology, capital and resources. Through transnational cooperation, enterprises are able to integrate global resources, strengthen the global competitiveness of the agricultural industry chain and lay a solid foundation for the internationalization of agriculture.

3. Technical cooperation. Technical cooperation is a key support in the internationalization of agriculture, which not only enhances the international competitiveness of domestic agricultural enterprises, but also promotes the technological progress of global agriculture. This is reflected in the following aspects:

a. Technology export and knowledge transfer. Through technical cooperation, agricultural enterprises can transfer domestic advanced agricultural technologies to other countries and introduce advanced technologies from cooperating countries. This two-way technology exchange can improve the agricultural production efficiency of the cooperating countries and help Chinese agribusinesses to enhance their technological advantages.

b. Agricultural infrastructure development. Technical cooperation can help cooperating countries to improve their agricultural infrastructure, such as irrigation systems and the construction of farmland, etc., whose development supplies material support for enhancing agricultural productivity and drives the advancement of agricultural modernization.

c. Talent training and technology exchanges. Through dispatching technical personnel, organizing training programs and establishing international technical cooperation platforms, technical cooperation not only helps the cooperating countries to improve their agricultural technology level, but also cultivates professional talents who can adapt to the international market for China's agricultural enterprises, and promotes the sharing of global agricultural technology.

d. Promotion of sustainable development technologies: As global attention to the issue of sustainable agricultural development increases, technical cooperation is of great importance in the promotion of green agricultural technologies. By promoting the diffusion of technologies that conserve water, energy and reduce the use of chemical fertilizers and pesticides, technical cooperation can help global agriculture to achieve environmentally friendly development goals.

In the process of China's agricultural internationalization, government-led efforts, enterprise investment and technical cooperation all have their distinct and significant roles. The government provides strategic protection for agricultural internationalization through policy support and the construction of international cooperation platforms; enterprises promote the development of the agricultural industry globally through capital investment, technological innovation and market expansion; and Technical cooperation offers technical assistance for the sustainable development of global agriculture through knowledge transfer and infrastructure construction. The close collaboration among the three forms a multidimensional synergistic model of agricultural internationalization, which promotes China's agriculture to take its place in the global market, and Simultaneously facilitates the realization of global food security and sustainable development goals.

In accordance with abovementioned five goals of Chinese agricultural policy, the following strategic pillars could be distinguished:

I. Agricultural Trade Expansion.

II. Overseas Agricultural Investment

III. Agricultural Technology Transfer & Innovation

IV. Infrastructure & Logistics Development

V. Policy Coordination & International Cooperation

The set of actions within these pillars are highlighted in Figure 3.8. However, the main attention should be paid to international cooperation for sustainable agriculture: transnational cooperation, technological innovation and standardization for sustainable development in global agriculture

Against the backdrop of growing global concern for agricultural sustainability, promoting cooperation on sustainable agriculture has become a key way to address global food security and environmental issues. China, being a major agricultural nation, is actively taking part in and promoting the internationalization of agriculture and advancing the sustainable development of global agriculture through its core model.

Potential case in the frame of this strategy is establishment of transnational agricultural cooperation parks. As an effective platform for promoting international agricultural cooperation, technology transfer and industry chain integration, transnational agricultural cooperation parks have become an important way to promote agricultural modernization and efficiency. Specifically, transnational agricultural cooperation parks have the potential to make contributions in the following aspects:

– Complementarity of resources and exchange of advantages: Through the establishment of transnational cooperation parks, different countries can cooperate on the basis of their respective resource endowments and technological advantages. Such cooperation enables the optimization of the allocation of agricultural resources, especially in countries where agricultural technology is relatively backward, so that they can obtain technical support from advanced countries, thus enhancing the productive capacity and competitiveness of local agriculture.

– Synergistic development of the industrial chain: Transnational cooperation parks can realize the scale and modernization of agricultural production. Through resource integration, agricultural enterprises can reduce production costs and enhance the efficiency of agricultural production and logistics, while avoiding the waste of resources. In addition, transnational cooperation promotes the integration of agricultural production models from different regions.

– Promoting the application of green agricultural technologies: The Cooperative Park offers a platform for the advancement of green agricultural technologies, like precision agriculture technologies and soil protection technologies. The utilization of these technologies not only enhances the efficiency of agricultural production, but also lowers the consumption of resources and mitigates environmental pollution during agricultural production, thus facilitating the sustainable development of agriculture.

– Policy coordination and win-win cooperation: The construction of transnational agricultural cooperation parks cannot be separated from government support and policy guarantee. Policy coordination among governments can provide a stable policy environment for the operation of transnational agricultural cooperation parks and ensure the balance of interests and the sustainable development of all parties involved.

The internationalization of green agricultural standards is a necessary measure to achieve sustainable development in global agriculture. Through the establishment of globally harmonized green agricultural standards, it is possible to ensure that agricultural production is carried out in an environmentally friendly and resource-efficient manner.

Globally harmonized green agricultural standards not only promote cooperation among countries in the agricultural sector, but also provide agricultural producers with clear guidelines on environmental protection and sustainability. These standards cover all aspects of production, processing and distribution, ensuring that the global agricultural chain follows green principles while enhancing production efficiency [225].

An internationalized green agricultural certification system can help to increase the market value of agricultural products. Through certification, agricultural products can demonstrate to consumers that their production processes meet environmental standards, which not only enhances market competitiveness but also encourages farmers and producers to adopt green production techniques.

Countries can accelerate the diffusion and application of green agricultural technologies through technology cooperation and sharing. International cooperation projects and technology exchange platforms provide support for green technologies in different countries, enabling their agriculture to realize a green transformation on a global scale.

Promoting the internationalization of green agricultural standards goes beyond the dissemination of technology and includes coordination and support at the policy level. Governments can promote sustainable development in the global agricultural sector by entering into international agreements to jointly develop and implement green agricultural standards on a global scale.

Although, South-South cooperation is an effective means of cooperation among developing countries in agriculture and related areas. By promoting South-South cooperation and strengthening cooperation with other developing countries, China is committed to enhancing global agricultural productivity and resource utilization efficiency. Specific pathways for South-South cooperation include:

1. Sharing of technology and experience. The core of South-South cooperation lies in the exchange of technology and experience, especially in the area of agriculture. China has exported advanced agricultural technology and experience to other developing countries in the form of foreign aid, agricultural technical cooperation and agricultural training, helping those countries to enhance agricultural productivity and sustainability.

2. Jointly addressing climate change and environmental challenges. Climate change has become an important challenge to global agricultural production, and South-South cooperation can help developing countries to jointly address this challenge. Through joint research and development of adaptive agricultural technologies and the promotion of water management technologies, South-South cooperation can help to mitigate the impact of climate change on agriculture and promote the sustainable development of global agriculture.

3. Agricultural trade and market expansion. South-South cooperation provides developing countries with the opportunity to jointly develop international markets. By jointly promoting the export of agricultural products, developing countries are capable of enhancing the international market share of agricultural products, while realizing resource complementarity and market sharing, and enhancing the stability of the global agricultural market.

4. Promoting agricultural infrastructure development and investment. South-South cooperation is not limited to technology transfer, but also includes financial and infrastructure support. Through outward foreign direct investment (FDI) and other

avenues, China has offered financial assistance for the building of agricultural infrastructure in other developing nations. promoting the optimization of global agricultural production and supply chains.

The modalities of international cooperation on sustainable agriculture are mainly reflected in the establishment of transnational agricultural cooperation parks, the promotion of the internationalization of green agricultural standards and the strengthening of South-South cooperation. Through these avenues of cooperation, the sustainability of global agriculture has been significantly enhanced.

Conclusions to chapter 3

Currently, global agriculture is facing multiple challenges such as resource depletion, environmental pollution and climate change, Particularly, the finite character of soil and water resources and the environmental expenses of agricultural production have a significant influence on the long-term sustainable development of agriculture. Global agricultural production faces changing ecological pressures and innovative measures are needed to address these challenges. The global agricultural supply chain has been disturbed by elements like epidemics, wars and extreme weather. Particularly in the aspect of supply chain disruptions and logistical bottlenecks, the stability of agricultural production and distribution has encountered great threats, further affecting global food security.

The core of China's agricultural transformation includes agricultural science and technology innovation, the promotion of sustainable development models, agricultural financial support and rural land reform. Technological innovations, such as smart and precision agriculture, have driven up production efficiency; Simultaneously, new models, such as low-carbon and circular agriculture, are leading the greening of agriculture.

China's agricultural internationalization should follow the principle of self-sufficiency in basic food rations to ensure food security; adhere to the principle of a commodity economy to promote market-oriented development; and follow the principles of "gradualness" and "regulation" in the process of promoting agricultural internationalization. In promoting the internationalization of agriculture, it is necessary to follow the principles of "gradualism" and "regulation" to ensure the sustainable implementation of measures.

By promoting the internationalization of agriculture, China aims to narrow the income gap between urban and rural areas and promote the urbanization of the rural population, further attain sustainable development in agriculture. Simultaneously, in promoting the internationalization of agriculture, it is of great significance to safeguard natural resources and the environment in order to guarantee global food security and food self-sufficiency. The successful realization of agricultural internationalization relies on several conditions, among which is the degree of openness of China's market. the structure of dominant commodities, and the regional pattern of agricultural internationalization. Market access, the internationalization of agricultural business methods and the internationalization of technology and capital are all key factors driving the process of agricultural internationalization. China's cooperation model for the internationalization of agriculture emphasizes the multidimensional synergy of government-led, enterprise investment and technical cooperation. Through multidimensional collaboration, it not only enhances the capacity of agricultural production, but also boosts the exchange and development of agricultural science and technology, and promotes the deepening of global agricultural cooperation. China has promoted international cooperation on sustainable agriculture through the establishment of transnational agricultural cooperation parks, the internationalization of green agricultural standards and the strengthening of South-South cooperation. This model not only promotes the application of green technologies, but also provides technical support and resource sharing for developing countries, enhancing the sustainability of global agriculture.

The results of the Chapter 3 are summarized in author’s papers: [68-70, 74].

CONCLUSIONS

Current research provides a systematic survey of China's agricultural internationalization strategy, emphasizing its dual objectives of ensuring global food supply and embracing sustainable development. It offers a detailed exploration of how China addresses domestic food security challenges through internationalization, while also making significant contributions towards global goals such as the United Nations 2030 Agenda for Sustainable Development. The research uniquely frames China's agricultural policy as a key solution to pressing global challenges, including population growth, climate change, and food resource shortages.

The following conclusions can be derived from the research results:

1. Global agricultural development and sustainability are shaped by evolving strategies and practices intended to tackle challenges such as climate change, population growth, resource exhaustion, and ecological equilibrium. The ontology of agriculture highlights its integration within socio-ecological systems, progressing through phases from primitive to contemporary agriculture. Sustainable practices focus on optimizing resource use, enhancing efficiency, and maintaining environmental health, while balancing economic viability and social equity. Internationalization of agriculture, supported by trade, investment, and cooperation theories, promotes technological diffusion, resource optimization, and global collaboration, though it also introduces challenges like dependency and unequal access, emphasizing the need for inclusive global governance to ensure food security and sustainability.

2. Theoretical models of agricultural progress and internationalization emphasize the dual goals of increasing agricultural productivity and ensuring sustainability. Key dimensions include technological innovation, resource efficiency, ecological protection, economic optimization, and supportive policies. Foundational theories, such as Malthus's population-food balance and Boserup's agricultural intensification, highlight the interplay between population growth and technological advancement, as seen in historical cases like the Green Revolution. Modern globalization drives agricultural progress through

trade, technology transfer, investments, and global policy coordination, while theoretical frameworks like comparative advantage, global value chains, and food sovereignty offer diverse approaches to internationalized agricultural systems.

3. The evolution of agricultural development strategies reflects a transition from subsistence-based systems during the pre-industrial period to more complex, globalized approaches aimed at ensuring food security amid environmental and societal challenges. Key stages include the Industrial Revolution, which introduced mechanization and monoculture policies; the Green Revolution, focusing on technological innovations like high-yield crops and irrigation systems; and sustainable intensification, which prioritizes productivity with environmental balance. Incorporating agriculture into global frameworks, like the Sustainable Development Goals, highlights the importance of ecological sustainability, poverty reduction, and global partnerships. The strategies adopted by major players such as the United States, European Union, Japan, and China demonstrate diverse approaches, emphasizing technological innovation, trade policies, and regional cooperation to address food security and support sustainable development globally.

4. The analysis of Chinese agricultural development highlights significant regional disparities, primarily revealed through a detailed cluster analysis of provinces based on economic, demographic, and agricultural output indicators. Using hierarchical clustering and the Ward's linkage method, the study identified distinct patterns of agricultural and economic activity across five major clusters of provinces. These clusters range from highly developed urban trade centers like Guangdong and Shanghai, characterized by low agrarian output, to agriculture-dominant regions such as Heilongjiang and Henan, recognized for their substantial contribution to national food production. This clustering underscores the importance of regional specialization and structural optimization in addressing the diverse agricultural challenges and opportunities across China.

5. The People's Republic of China has played a crucial role in the global agricultural development by advancing sustainable practices and promoting international trade. With

a focus on structural optimization, increased production efficiency, and integration into the global agricultural system, China has played a vital part in guaranteeing food security through the import and export of essential goods, including corn, soybeans, and aquaculture products. The country's agricultural trade strategy, underpinned by theories like comparative advantage and trade liberalization, emphasizes diversification, technological innovation, and policy support. Furthermore, China has established strong partnerships with major agricultural suppliers, including Ukraine, which provides essential commodities and plays a critical role in sustaining China's food supply chain. Through initiatives such as precision agriculture and ecological farming, China aims to modernize its agriculture while addressing global challenges related to resource constraints, trade volatility, and environmental sustainability.

6. China has become a crucial actor in the international transfer of agricultural capital, employing strategies like foreign direct investment (FDI), technology exports, trade networking, and public-private partnerships to enhance global agricultural production and infrastructure. Through initiatives like the Belt and Road, China has supported sustainable development, food security, and modernization in regions such as Africa, Southeast Asia, and Latin America, while also addressing challenges like market risks, cultural adaptation, and environmental sustainability. China's engagement spans land leasing, partnerships with multinational corporations, and exporting technologies like hybrid rice and smart irrigation systems, boosting agricultural capacity and fostering global cooperation.

7. Agricultural development faces global challenges, including population growth, resource scarcity, climate change, soil degradation, and water scarcity, which strain food production and sustainability. These challenges require innovative solutions such as precision agriculture, biotechnology, efficient irrigation systems, and international cooperation to enhance productivity and resilience. Disparities in soil health, access to modern technologies, and infrastructure between regions further emphasize the need for sustainable practices and collaboration. Countries like the U.S., EU, Israel, and Brazil

have adopted strategies such as precision agriculture, organic farming, and low-carbon initiatives to address these issues, while global agricultural supply chains face vulnerabilities from epidemics, conflicts, and extreme weather events.

8. Agricultural transformation of China focuses on five key areas aimed at modernizing and globalizing the sector. First, advancements in science, technology, and innovation are being employed to boost productivity and efficiency. Second, sustainable agricultural development is promoted through eco-agriculture, circular agriculture, and low-carbon practices that reduce environmental impact and conserve resources. Third, financial support mechanisms, including agricultural insurance, credit, and industrial funds, are being strengthened to facilitate agricultural modernization and internationalization. Fourth, reforms in rural land and business models are enhancing land use and production efficiency. Lastly, upgrading the agricultural industry chain is a priority, focusing on deep processing of products, brand cultivation, export standard convergence, and cross-border e-commerce development to increase value-added output and global competitiveness.

9. China's strategy of agricultural internationalization is a multifaceted approach aimed at ensuring food security, promoting sustainable agriculture, boosting international trade and investment, advancing technological transfer, and supporting rural development globally. Guided by principles of government leadership, enterprise investment, and technical cooperation, the strategy involves policy planning, infrastructure development, and international diplomacy. It is implemented through five strategic pillars: expanding agricultural trade to diversify import sources and strengthen trade agreements; investing in overseas agricultural zones, particularly in Africa, Latin America, and Southeast Asia; promoting agricultural technology transfer and innovation through joint research and smart farming; enhancing logistics and infrastructure to reduce post-harvest losses and modernize rural areas; and coordinating international policies by aligning with global institutions like the FAO and the Belt and Road Initiative. This integrated approach positions China as a key player in shaping global agricultural development.

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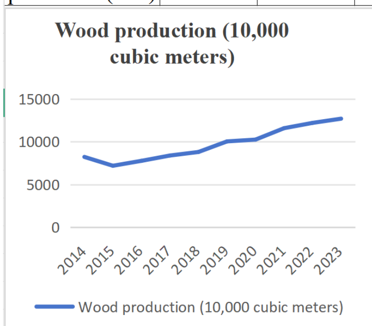
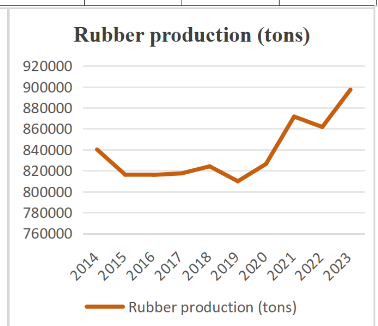
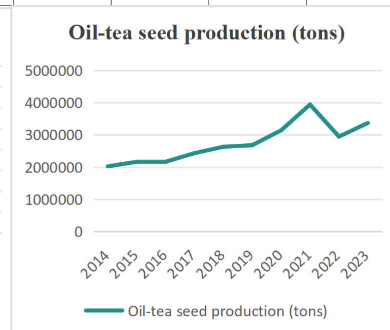
ANNEXES

Annex A

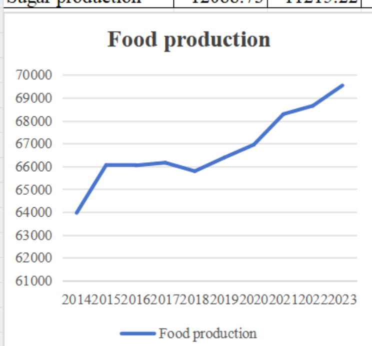
A	B	C	D	E	F	G	H	I	J	K
Output of major forestry products										
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Wood production (10,000 cubic meters)	8233	7200	7776	8398	8811	10046	10257	11589	12210	12701
Rubber production (tons)	840171	816103	815918	817366	824093	809859	826348	871600	861675	897323
Oil-tea seed production (tons)	2023445	2163492	2164440	2431647	2629796	2679270	3141620	3942376	2946191	3369641

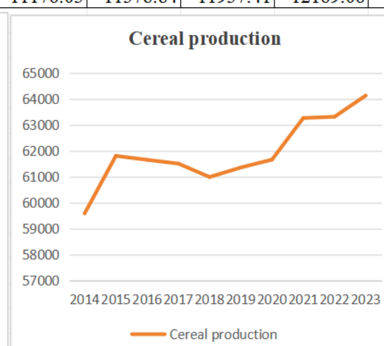


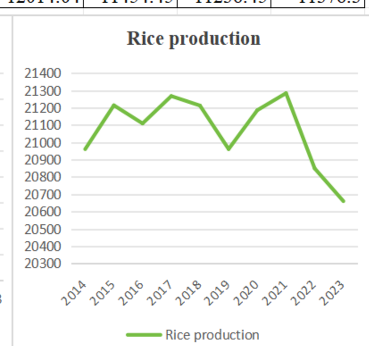


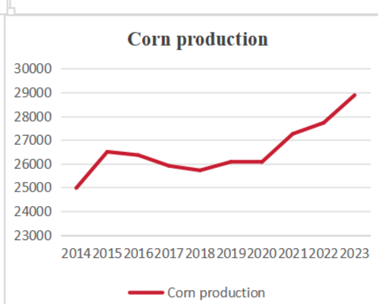


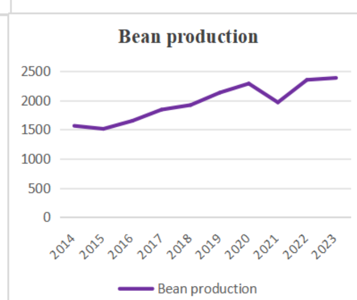
A	B	C	D	E	F	G	H	I	J	K
Output of major crops (10,000 tons)										
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Food production	63964.83	66060.27	66043.51	66160.73	65789.22	66384.34	66949.15	68284.75	68652.77	69540.99
Cereal production	59601.54	61818.41	61666.53	61520.54	61003.58	61369.73	61674.28	63275.69	63324.34	64143.01
Rice production	20960.91	21214.19	21109.42	21267.59	21212.9	20961.4	21185.96	21284.24	20849.48	20660.32
Wheat production	12823.52	13255.52	13318.83	13424.13	13144.05	13359.63	13425.38	13694.45	13772.34	13659.01
Corn production	24976.44	26499.22	26361.31	25907.07	25717.39	26077.89	26066.52	27255.06	27720.3	28884.23
Bean production	1564.52	1512.52	1650.66	1841.56	1920.27	2131.9	2287.46	1965.52	2351.03	2384.1
Cotton production	629.94	590.74	534.28	565.25	610.28	588.9	591.05	573.09	598.02	561.79
Oil production	3371.92	3390.47	3400.05	3475.24	3433.39	3492.98	3586.4	3613.17	3654.21	3863.66
Peanut production	1590.08	1596.13	1636.06	1709.19	1733.2	1751.96	1799.27	1830.78	1832.95	1923.07
Sugar production	12088.73	11215.22	11176.03	11378.84	11937.41	12169.06	12014.04	11454.45	11236.45	11376.3



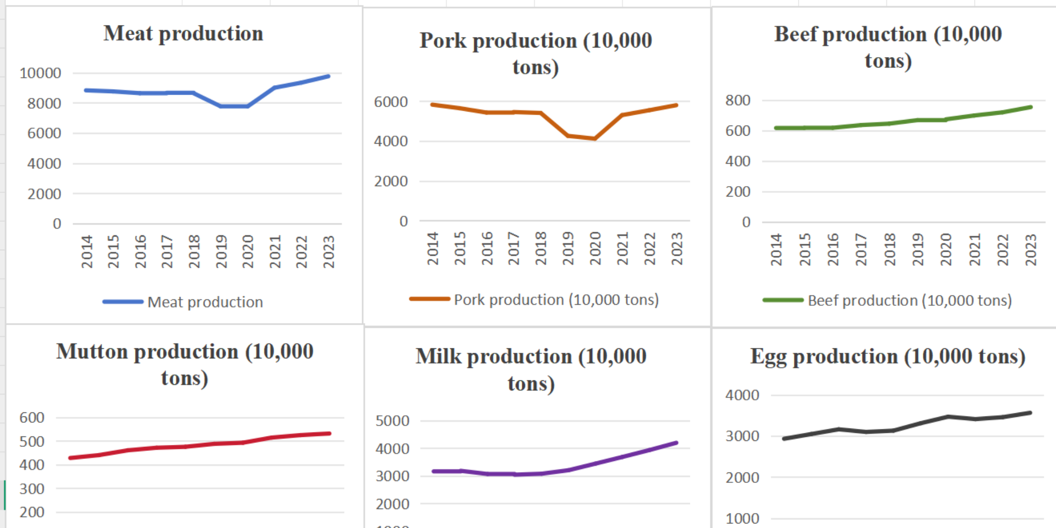






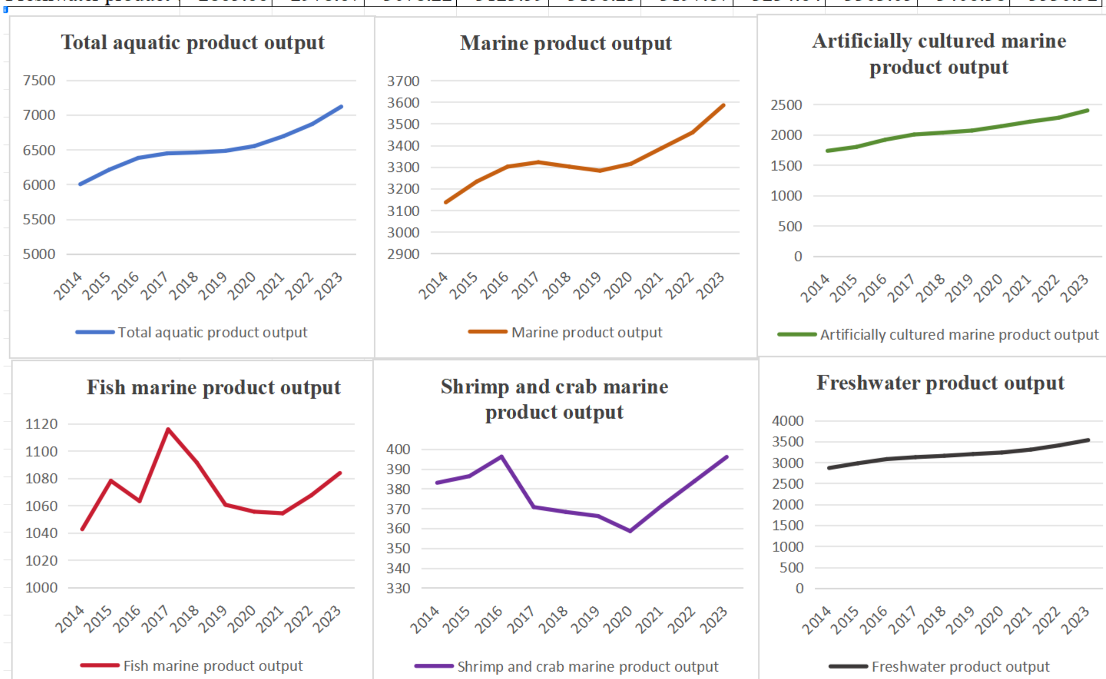


A	B	C	D	E	F	G	H	I	J	K
Indicator	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Meat production	8817.9	8749.52	8628.33	8654.43	8624.63	7758.78	7748.38	8989.99	9328.44	9748.23
Pork production (10,000 tons)	5820.8	5645.41	5425.49	5451.8	5403.74	4255.31	4113.33	5295.93	5541.43	5794.32
Beef production (10,000 tons)	615.72	616.89	616.91	634.62	644.06	667.28	672.45	697.51	718.26	752.68
Mutton production (10,000 tons)	427.63	439.93	460.25	471.07	475.07	487.52	492.31	514.08	524.53	531.26
Milk production (10,000 tons)	3159.88	3179.83	3064.03	3038.62	3074.56	3201.24	3440.14	3682.7	3931.63	4196.65
Egg production (10,000 tons)	2930.31	3046.13	3160.54	3096.29	3128.28	3308.98	3467.76	3408.81	3456.38	3562.99



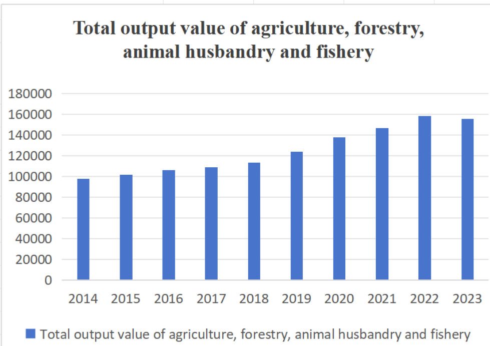
Output of major aquatic products

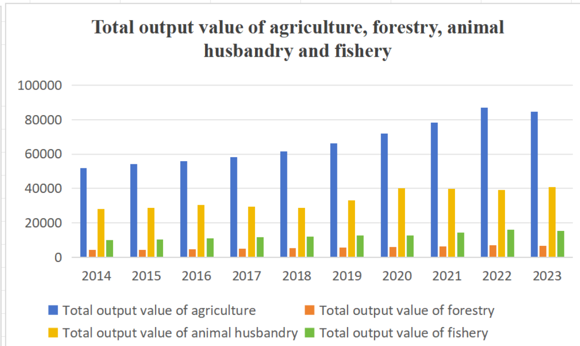
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total aquatic produc	6001.92	6210.97	6379.48	6445.33	6457.66	6480.36	6549.02	6690.3	6865.91	7116.24
Marine product outp	3136.25	3232.29	3301.26	3321.74	3301.43	3282.5	3314.38	3387.25	3459.53	3585.32
Artificially cultured	1732.4	1796.56	1915.31	2000.7	2031.22	2065.33	2135.31	2211.14	2275.7	2395.6
Fish marine product	1042.52	1078.02	1063.15	1115.78	1091.48	1060.48	1055.41	1054.18	1067.4	1083.76
Shrimp and crab mai	382.95	386.28	396.09	370.71	368.24	366.18	358.58	371.63	383.78	395.96
Freshwater product (	2865.66	2978.67	3078.22	3123.59	3156.23	3197.87	3234.64	3303.05	3406.38	3530.92



Annex B

A	B	C	D	E	F	G	H	I	J	K
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total output value of agriculture, forestry, animal husbandry and fishery	97822.51	101893.52	106478.73	109331.72	113579.53	123967.94	137782.17	147013.4	158507.17	156065.94
Total output value of agriculture	51851.12	54205.34	55659.89	58059.76	61452.6	66066.45	71748.23	78339.51	87073.38	84438.58
Total output value of forestry	4189.98	4358.45	4635.9	4980.55	5432.61	5775.71	5961.58	6507.7	7006.08	6820.83
Total output value of animal husbandry	27963.39	28649.32	30461.17	29361.19	28697.4	33064.35	40266.67	39910.83	38964.6	40652.36
Total output value of fishery	9877.54	10339.09	10892.92	11577.09	12131.51	12572.4	12775.86	14507.27	16116.19	15467.98





Annex C

China's import and export volume of agricultural products in the same period in the past five years (USD 100 million)

Year	Imports	Exports
2019	1498.55	785.72
2020	1708.73	760.63
2021	2198.16	843.51
2022	2360.57	982.62
2023	2341.06	989.29

2023	Export	the same period growth rate	Import	the same period growth rate
January	77.33	-0.145	208.55	-0.015
February	67.09	0.294	176.89	0.236
March	89.21	0.166	200.45	0.15
April	82.26	0.032	200.40	0.053
May	80.93	-0.074	227.59	0.021
June	78.60	-0.063	211.63	0.042
July	81.05	-0.054	187.48	-0.102
August	81.40	-0.02	187.04	-0.079
September	83.28	0.017	179.77	-0.121
October	82.79	0.004	168.67	-0.009
November	91.35	0.04	185.57	-0.1
December	94.00	0.022	207.01	-0.069

Annex D

A	B	C	D	E	F	G	H	I	J	K
				Output of major crops (10,000 tons)						
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Food production	63964.83	66060.27	66043.51	66160.73	65789.22	66384.34	66949.15	68284.75	68652.77	69540.99
Cereal production	59601.54	61818.41	61666.53	61520.54	61003.58	61369.73	61674.28	63275.69	63324.34	64143.01
Rice production	20960.91	21214.19	21109.42	21267.59	21212.9	20961.4	21185.96	21284.24	20849.48	20660.32
Wheat production	12823.52	13255.52	13318.83	13424.13	13144.05	13359.63	13425.38	13694.45	13772.34	13659.01
Corn production	24976.44	26499.22	26361.31	25907.07	25717.39	26077.89	26066.52	27255.06	27720.3	28884.23
Bean production	1564.52	1512.52	1650.66	1841.56	1920.27	2131.9	2287.46	1965.52	2351.03	2384.1
Cotton production	629.94	590.74	534.28	565.25	610.28	588.9	591.05	573.09	598.02	561.79
Oil production	3371.92	3390.47	3400.05	3475.24	3433.39	3492.98	3586.4	3613.17	3654.21	3863.66
Peanut production	1590.08	1596.13	1636.06	1709.19	1733.2	1751.96	1799.27	1830.78	1832.95	1923.07
Sugar production	12088.73	11215.22	11176.03	11378.84	11937.41	12169.06	12014.04	11454.45	11236.45	11376.3

A	B	C	D	E	F	G
Indicators	2018	2019	2020	2021	2022	2023
Fruit production	25688.4	27400.8	28692.4	29970.2	31296.2	32744.3
Vegetable production	70346.7	72102.6	74912.9	77548.8	79997.2	82868.1
Tea production	261.04	277.72	293.18	316.4	334.21	354.11
Oil production	3492.98	3433.39	3475.24	3400.05	3390.47	3371.92

Output of major livestock products (10,000 tons)

Indicator	2018	2019	2020	2021	2022	2023
Meat production	8624.63	7758.78	7748.38	8989.99	9328.44	9748.23
Pork production (10,000	5403.74	4255.31	4113.33	5295.93	5541.43	5794.32
Beef production (10,000	644.06	667.28	672.45	697.51	718.26	752.68
Mutton production	475.07	487.52	492.31	514.08	524.53	531.26
Milk production (10,000	3074.56	3201.24	3440.14	3682.7	3931.63	4196.65
Egg production (10,000	3128.28	3308.98	3467.76	3408.81	3456.38	3562.99

Indicators	2018	2019	2020	2021	2022	2023
Wood production (10,000	8811	10046	10257	11589	12210	12701
Rubber production (tons)	824093	809859	826348	871600	861675	897323
Oil-tea seed production	2629796	2679270	3141620	3942376	2946191	3369641

Output of major crops (10,000 tons)

Indicators	2018	2019	2020	2021	2022	2023
Food production	65789.2	66384.3	66949.2	68284.8	68652.8	69541
Cereal production	61003.6	61369.7	61674.3	63275.7	63324.3	64143
Rice production	21212.9	20961.4	21186	21284.2	20849.5	20660.3
Wheat production	13144.1	13359.6	13425.4	13694.5	13772.3	13659
Corn production	25717.4	26077.9	26066.5	27255.1	27720.3	28884.2
Bean production	1920.27	2131.9	2287.46	1965.52	2351.03	2384.1
Cotton production	610.28	588.9	591.05	573.09	598.02	561.79
Oil production	3433.39	3492.98	3586.4	3613.17	3654.21	3863.66
Peanut production	1733.2	1751.96	1799.27	1830.78	1832.95	1923.07
Sugar production	11937.4	12169.1	12014	11454.5	11236.5	11376.3

Indicators	2018	2019	2020	2021	2022	2023
Total aquatic product	6457.66	6480.36	6549.02	6690.3	6865.91	7116.24
Marine product output	3301.43	3282.5	3314.38	3387.25	3459.53	3585.32
Artificially cultured	2031.22	2065.33	2135.31	2211.14	2275.7	2395.6
Fish marine product	1091.48	1060.48	1055.41	1054.18	1067.4	1083.76
Shrimp and crab marine	368.24	366.18	358.58	371.63	383.78	395.96
Freshwater product	3156.23	3197.87	3234.64	3303.05	3406.38	3530.92

Annex E

Gross Out value of Agriculture,Forestry,Animal_Husbandry and Fishery and Related Indices

(100 millions Yuan)

Region	2022	2021	2020	2019	2018	2017	2016	2015	2014
Beijing	268.18	269.51	263.43	281.7	296.77	308.32	338.06	368.24	420.07
Tianjin	521.44	509.26	476.44	414.35	390.5	382.07	395.57	378.44	367.75
Hebei	7667.41	7018.67	6742.49	6061.46	5707	5373.38	5299.66	5291.68	5373.76
Shanxi	2211.59	2134.02	1935.84	1626.54	1460.64	1418.73	1429.91	1424.96	1440.6
Inner Mongolia	4316.76	3815.12	3472.36	3176.34	2985.32	2813.54	2803.55	2761.56	2786.54
Liaoning	5180.03	4927.73	4582.56	4368.25	4061.93	3851.62	3764.09	4057.59	3949.39
Jilin	3217.91	2972.32	2976	2442.73	2184.34	2064.29	2167.89	2292.97	2302.04
Heilongjiang	6718.24	6459.97	6438.11	5929.97	5624.29	5586.63	5202.87	5030.06	4865.8
Shanghai	273.53	268.93	279.82	284.84	289.58	292.61	300.84	327.71	343.78
Jiangsu	8733.8	8279.72	7952.59	7503.15	7192.46	7161.21	7178.96	6980.37	6402.75
Zhejiang	3752.31	3579.21	3496.94	3355.25	3157.25	3093.36	3038.49	2845.56	2773.7
Anhui	6277.98	6004.31	5680.91	5162.13	4672.71	4597.94	4432.32	4183.14	4024.2
Fujian	5502.56	5200.97	4901.07	4636.56	4229.52	3947.16	3784.24	3399.3	3247.11
Jiangxi	4223.81	3998.09	3820.74	3481.29	3148.57	3069.01	3019.87	2808.37	2670.18
Shandong	12130.71	11468.01	10190.58	9671.67	9397.39	9140.36	9075.6	9283.92	8988.18
Henan	10952.24	10501.2	9956.35	8541.77	7757.94	7562.53	7405.42	7299.58	7244.34
Hubei	8939.33	8296.44	7303.64	6681.85	6207.83	6129.72	5863.98	5387.13	5162.94
Hunan	8160.13	7662.36	7511.96	6405.06	5361.62	5213.48	5057.52	4682.31	4577.08
Guangdong	8892.29	8305.84	7901.92	7175.89	6318.12	5969.87	5817.55	5303.63	5053.72
Guangxi	6938.53	6524.39	5913.28	5498.81	4909.24	4698.71	4560.2	4197.12	3947.73
Hainan	2272.04	2014.79	1821.02	1689.4	1535.73	1488.86	1433.88	1294	1227.14
Chongqing	3068.45	2935.65	2749.05	2337.81	2052.41	1902.47	1851.6	1609.05	1485.78
Sichuan	9859.75	9383.32	9216.4	7889.35	7195.65	6955.55	6816.92	6377.84	5888.09
Guizhou	4908.67	4691.97	4358.62	3888.99	3619.52	3413.86	3123.13	2740.93	2120.27
Yunnan	6635.8	6351.82	5920.52	4935.73	4108.88	3872.93	3704.69	3438.73	3307.82
Tibet	278.62	255.34	233.53	212.81	195.47	178.16	172.97	149.46	138.72
Shaanxi	4601.93	4313.44	4056.61	3536.8	3239.99	3077.62	2994.83	2821.56	2748.59
Gansu	2680.74	2439.54	2103.61	1887.58	1659.36	1559.64	1443.12	1386.18	1307.31
Qinghai	566.21	528.53	507.1	454.35	405.93	364.1	338.8	319.27	327.49
Ningxia	845.92	759.81	703.07	584.85	575.77	517.42	496.27	484.46	448.18
Xinjiang	5469.04	5143.12	4315.61	3850.65	3637.79	3326.59	3165.92	2968.39	2881.48

Annex F

Total Investment of Foreign Funded Enterprisies(USD million)

Region	2022	2021	2020	2019	2018	2017	2016	2015	2014
Beijing	754000	717200	646907	599561	547718	486409	427371	380963	201027
Tianjin	305700	1021700	306423	310544	290620	254823	222594	181328	144146
Hebei	266700	235400	225402	158991	108665	95818	84821	73624	62135
Shanxi	61700	89000	92559	70136	63011	49724	42163	41107	39119
Inner Mongolia	50600	60600	56084	58421	44853	45979	41080	35142	26449
Liaoning	517100	460300	415731	402830	377494	315850	213278	206639	198641
Jilin	126400	143800	70774	64297	49009	38874	35606	35230	33328
Heilongjiang	179800	173400	168558	46046	42747	33669	28280	22302	23983
Shanghai	1255900	1215500	1033395	955229	884911	798239	734246	661273	530467
Jiangsu	1491600	1430900	1369729	1173515	1056042	965819	879868	782154	718131
Zhejiang	706900	667300	589264	500693	445788	373415	319870	291813	262881
Anhui	338700	324800	322704	165643	112984	86641	67256	106486	48026
Fujian	394000	337200	315255	297471	278698	260721	226315	196713	173245
Jiangxi	161200	151800	133086	100985	87720	80797	77738	72578	67025
Shandong	2551700	1632800	1207308	575432	345229	304218	251874	219334	199227
Henan	103000	105200	111920	116307	105408	104538	82249	68710	58878
Hubei	252800	232700	237071	186438	142275	115103	99316	89231	77671
Hunan	246400	235700	214906	184126	183185	163392	58000	52147	46307
Guangdong	2414100	2328500	2167181	1953252	1923465	1762227	781571	644310	562063
Guangxi	970700	900600	289389	91640	62723	56200	43720	42529	37396
Hainan	5670400	4527200	2744956	104528	92793	76089	76039	31174	27888
Chongqing	156000	133500	123895	111070	110686	94558	88065	78845	67517
Sichuan	268200	238600	296279	289060	125557	112797	94193	88409	82752
Guizhou	214700	94600	83573	48722	45303	31251	23719	18147	15472
Yunnan	236900	164100	142431	67099	54369	37382	33005	32720	25253
Tibet	2700	2700	2859	2665	2639	3031	2259	1997	1328
Shaanxi	200500	195500	183272	121290	118786	80039	56081	51571	44734
Gansu	41000	41800	25931	25617	23617	20197	7529	7657	6764
Qinghai	10800	10200	7819	7834	7874	7699	7527	7396	3095
Ningxia	30400	28000	26993	26463	18477	30420	8707	8972	5164
Xinjiang	61600	56800	32042	24123	21151	13323	9666	8518	7586

Annex G

The area sown to the crops

Region	2022	2021	2020	2019	2018	2017	2016	2015	2014
Beijing	143.81	117.85	98.18	88.55	103.79	120.94	145.55	172.14	194.64
Tianjin	443.51	437	419.17	410.27	429.27	439.52	443.66	433.28	443.01
Hebei	8113.99	8097.2	8089.44	8132.69	8197.13	8381.65	8467.51	8457.76	8454.9
Shanxi	3611.59	3587.95	3541.51	3524.42	3555.16	3577.62	3591.54	3612.65	3664.57
Inner Mongolia	8750.68	8743.34	8882.81	8885.02	8824.07	9014.22	8957.21	8423.68	8079.08
Liaoning	4326.86	4328.94	4287.78	4217.1	4207.11	4172.32	4242.73	4335.47	4219.8
Jilin	6226.36	6187.06	6150.99	6117.05	6080.89	6086.2	6063.25	5997.91	5890.5
Heilongjiang	15209.41	15065.03	14910.13	14770.08	14673.33	14767.59	14829.46	14811.88	14497.68
Shanghai	269.17	264.35	255.16	261.39	282.27	284.95	303.78	350.64	369.91
Jiangsu	7534.24	7514.45	7478.4	7442.63	7520.23	7556.4	7639.9	7693.7	7615.79
Zhejiang	2027.16	2014.59	2014.5	1999.62	1978.68	1981.11	1946.46	1977.8	1986.77
Anhui	8933.59	8886.77	8817.99	8781.96	8771.11	8726.68	8790.1	9598.29	9500.18
Fujian	1682.14	1651.87	1631.27	1599.29	1577.31	1549.34	1548.8	1617.17	1670.17
Jiangxi	5730.55	5672.94	5644.37	5521.18	5555.81	5638.46	5668.88	5688.41	5667.34
Shandong	10964.14	10948.59	10889.06	10933.09	11076.8	11107.79	11278.61	11381.01	11316.65
Henan	14711.51	14705.13	14687.99	14713.98	14783.35	14732.53	14902.72	14879.73	14731.54
Hubei	8191.92	8109.24	7974.39	7815.89	7952.9	7956.14	7908.5	7983.43	7791.42
Hunan	8591.54	8504.26	8400.13	8122.79	8111.09	8321.97	8341.5	8355.22	8398.63
Guangdong	4553.47	4498.36	4451.81	4357.38	4279.36	4227.51	4181.56	4194.55	4225.19
Guangxi	6271.4	6177.52	6107.32	5989.21	5972.38	5969.88	5966.74	6078.81	5855.03
Hainan	687.18	684.78	676.86	676.24	712.94	709.44	731.9	757.5	779.4
Chongqing	3479.02	3409.26	3372.54	3345.74	3348.49	3339.56	3333.1	3311.32	3288.58
Sichuan	10227.36	9999.92	9849.89	9692.98	9615.32	9575.05	9493.82	9451.06	9377.7
Guizhou	5359.45	5422.88	5475.35	5481.56	5477.16	5659.37	5604.8	5532.9	5510.5
Yunnan	7130.63	7057.24	6989.67	6938.86	6890.77	6790.8	6786.62	6818.64	6842.84
Tibet	277.24	274.19	272.08	271.53	270.38	254.05	263.15	229.69	227.1
Shaanxi	4212.23	4189.27	4160.85	4132.09	4091.01	4063.88	4160.15	4050	4053.87
Gansu	4061.94	3997.94	3931.82	3831.57	3773.55	3752.03	3749.2	3768.38	3775.83
Qinghai	586.19	583.87	571.42	553.54	557.25	555.31	557.75	558.39	553.7
Ningxia	1189.49	1175.91	1174.23	1152.96	1164.57	1132.63	1118.85	1132.43	1126.76
Xinjiang	6493.13	6387.42	6280.01	6169.99	6068.89	5886.96	5921.27	5175.47	5074.23

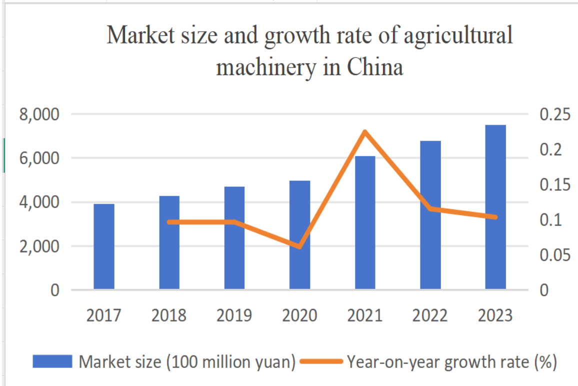
Annex H

Total Value of Imports and Exports(USD 10000)

Indicators	2022	2021	2020	2019	2018	2017	2016	2015	2014
Asia	316743198	306055687	238775903	236725767	238058298	212652448	194691029	209440911	227347807
Afghanistan	59229	52398	55519	62908	69167	54463	43583	37359	41093
Bahrain	200345	178052	126657	167948	128565	102647	85452	112339	141575
Bangladesh	2759819	2514134	1587545	1835982	1873748	1604417	1517163	1471155	1254338
Bhutan	16858	10877	1359	1096	1284	642	498	847	1122
Brunei	306399	286454	194222	110274	183946	98940	73257	150857	193653
Myanmar	2478239	1864603	1889432	1869905	1523211	1347481	1228639	1510021	2496893
Cambodia	1577619	1366552	955198	942585	738418	579078	476067	442999	375765
Cyprus	119698	89525	91828	63609	79211	57765	51014	63958	110015
Korea DPR	97288	31612	53892	278903	243021	497609	565300	551060	638758
HongKong, China	30166122	36023464	27955819	28821965	31052397	28652856	30395369	34320860	37569852
India	13468574	12565302	8769702	9281118	9550900	8438762	7017947	7159658	7057611
Indonesia	14853185	12457032	7846308	7976261	7734118	6333169	5354016	5422816	6354485
Iran	1568025	1478075	1493339	2303562	3504201	3713851	3124585	3382755	5184234
Iraq	5308178	3734298	3022675	3338866	3039860	2214453	1821145	2058386	2850508
Israel	2535321	2282854	1753921	1476915	1391557	1312470	1135396	1141798	1087974
Japan	35674000	37131703	31728000	31501321	32770921	30305294	27508069	27851902	31231185
Jordan	639629	441480	360724	411198	318367	308279	316599	371192	362774
Kuwait	3141028	2212401	1428293	1728379	1865651	1204772	937207	1126974	1343369
Laos	561798	434247	357957	391945	347215	302435	234671	277310	361736
Lebanon	252567	155662	97742	170561	201827	203365	211839	230285	263025
Macao,China	426058	329230	229166	311195	315327	327295	328151	477594	380527
Malaysia	20155781	17695996	13147574	12405176	10858103	9613842	8694141	9725772	10200563
Maldives	44074	41125	28147	38170	39721	29625	32118	17283	10437
Mongolia	1219839	913202	674264	816095	798900	640293	461124	536608	731847
Nepal	166037	197643	118374	151602	109937	98481	88868	86471	233065
Oman	4038178	3215685	1873593	2267110	2176312	1569973	1418911	1716381	2586124
Pakistan	2626680	2782488	1748254	1797305	1910540	2008401	1914706	1891665	1599835
Palestine	15587	12835	10046	8228	7381	6918	5962	6969	7559
Philippines	8648924	8204665	6121718	6096325	5564824	5130511	4723856	4563645	4445771
Qatar	2651988	1717168	1093626	1112279	1162880	808260	552874	689001	1059074
Saudi Arabia	11577680	8728985	6716515	7807244	6328242	5013688	4228130	5163398	6908327
Singapore	11306419	9392319	8924419	9003631	8276440	7926892	7052592	7952320	7973991
Korea Rep.	35999110	36224874	28558074	28453344	31339955	28025693	25270349	27579247	29044222
Sri Lanka	419137	590488	416049	448761	457679	439803	456177	456256	404107
Syria	42236	48363	83485	131522	127364	110415	91861	102616	98650
Thailand	13377063	13118721	9865398	9174649	8750835	8013781	7572743	7545955	7262116
Turkey	3832653	3420076	2407789	2082052	2154546	2190494	1947493	2155148	2301085
United Arab Emirates	9883578	7232493	4936517	4874963	4588902	4103512	4006689	4853420	5479786
Republic of Yemen	339057	305628	355536	368565	259454	230300	185844	232811	513417
Vietnam	23181824	23021449	19229008	16198556	14783304	12199187	9827573	9584877	8363641
P. R. China	12112566	15691161	12526628	12979220	14622157	13236937	12802993	14336931	14488044
Taiwan, China	31856351	32817343	26061536	22812207	22624292	19993912	17908843	18809668	19828375
Timor Leste	42534	37358	19249	16751	13540	13417	16461	10526	6044
Kazakhstan	3109028	2524982	2150823	2200277	1987814	1794313	1309767	1429019	2245167
Kirghizia	1542368	755374	290017	634656	561112	542386	567669	434069	529794
Tadzhikistan	257059	185862	106214	167469	150593	134811	175634	184742	251594
Turkmenistan	1117411	735743	651537	911688	843630	694324	590177	864313	1047044
Uzbekistan	970012	803706	662202	721287	626919	422087	361461	349583	427612

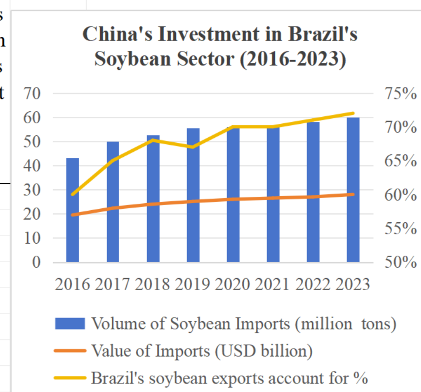
Annex I

Year	Market size (100 million yuan)	Year-on-year growth rate (%)
2017	3,911	
2018	4,286	9.59%
2019	4,698	9.61%
2020	4,983	6.07%
2021	6,100	22.42%
2022	6,800	11.48%
2023	7,500	10.29%

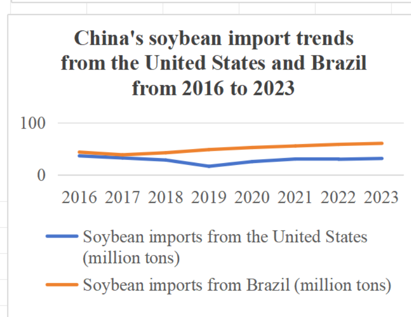


Annex J

Year	Volume of Soybean Imports (million tons)	Value of Imports (USD billion)	Brazil's soybean exports account for %
2016	43.2	19.5	60%
2017	50.1	22.3	65%
2018	52.6	24	68%
2019	55.4	25.1	67%
2020	56	26	70%
2021	56.5	26.5	70%
2022	58	27	71%
2023	60	28	72%



Year	Loan amount to Africa (US$ 100 million)	Loan amount to Southeast Asia (US$ 100 million)
2016	1	0.8
2017	1.2	1
2018	1.4	1.2
2019	1.6	1.4
2020	1.8	1.6
2021	2	1.8



Annex K

Indicators	2016	2017	2018	2019	2020	2021	2022	2023
Total grain output (10,000 tons)	61623.9	61791	65789	66384	66949	68285	68653	69541
Fruit output (10,000 tons)	24405.24	25241.9	25688.35	27400.84	28692.36	29970.2	31296.24	32744.28
Vegetable output (10,000 tons)	67434.16	69192.68	70346.72	72102.6	74912.9	77548.78	79997.22	82868.11
Meat output (10,000 tons)	8628.33	8654.43	8624.63	7758.78	7748.38	8989.99	9328.44	9748.23
Aquatic product output (10,000 tons)	6901	6445	6469	6480.36	6549	6690	6865.91	7116
Agriculture, forestry, animal husbandry and fishery added value (100 million yuan)	62451	64660	67558.7	73576.9	81396.5	86994.8	92576.8	94462.6
Agriculture, forestry, animal husbandry and fishery added value index (previous year = 100)	103.5	104.1	103.6	103.2	103.3	107.1	104.4	104.2

Annex L

A	B	C	D	E	F	G	H	I	J	K
Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cereal	59601.54	61818.41	61666.53	61520.54	61003.58	61369.73	61674.28	63275.69	63324.34	64143.01
Rice	20960.91	21214.19	21109.42	21267.59	21212.9	20961.4	21185.96	21284.24	20849.48	20660.32
Wheat	12823.52	13255.52	13318.83	13424.13	13144.05	13359.63	13425.38	13694.45	13772.34	13659.01
Corn	24976.44	26499.22	26361.31	25907.07	25717.39	26077.89	26066.52	27255.06	27720.3	28884.23
Vegetable	64948.65	66425.1	67434.16	69192.68	70346.72	72102.6	74912.9	77548.78	79997.22	82868.11
Fruit	23302.63	24524.62	24405.24	25241.9	25688.35	27400.84	28692.36	29970.2	31296.24	32744.28
Cotton	629.94	590.74	534.28	565.25	610.28	588.9	591.05	573.09	598.02	561.79
Tea	204.93	227.66	231.33	246.04	261.04	277.72	293.18	316.4	334.21	354.11
Sugar	12088.73	11215.22	11176.03	11378.84	11937.41	12169.06	12014.04	11454.45	11236.45	11376.3