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2026 China and Global Food Policy Report

AGFEP 全球食物经济与政策研究院
Academy of Global Food Economics and Policy

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# CHINA AND GLOBAL FOOD POLICY REPORT 2026

# REFRAMING RESILIENCE FOR STRENGTHENING AGRIFOOD SYSTEMS


# Academy of Global Food Economics and Policy, China Agricultural University

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The Academy of Global Food Economics and Policy (AGFEP) is a directly affiliated institute of China Agricultural University. The institute is headed by Dr. Shenggen Fan, Chair Professor at China Agricultural University and former Director General of the International Food Policy Research Institute (IFPRI). The members of AGFEP include faculty members and researchers from China Agricultural University, Zhejiang University, Beijing University and AgroScope, Switzerland. The academic committee of AGFEP is composed of 14 scholars from both domestic and international communities, specializing in food policy, environmental science, nutrition, and agricultural economics.

AGFEP features a close integration of the global agenda and China's practices, a multidisciplinary research approach, and a management mechanism emphasizing collaboration and talent development. AGFEP focuses on food systems transformation and aims to share China's experience and lessons with the world. The key research areas include reshaping global and Chinese food systems, analyzing responses to unexpected public emergencies, and exploring the food-economy-environment-health nexus. The academy provides forward-looking and evidence-based strategic policy options for China as well as the global community.


2021 China and Global Food Policy Report: Rethinking Agrifood Systems for the Post-COVID World


2022 China and Global Food Policy Report: Reforming Agricultural Support Policy for Transforming Agrifood Systems


2023 China and Global Food Policy Report: Promoting Sustainable Healthy Diets for Transforming Agrifood Systems


2024 China and Global Food Policy Report: Building a Sustainable and Diversified Food Supply to Foster Agrifood Systems Transformation


2025 China and Global Food Policy Report: Low-carbon Transformation of Chinese Agrifood Systems

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CHINA AND GLOBAL FOOD POLICY REPORT 2026

# REFRAMING RESILIENCE FOR STRENGTHENING AGRIFOOD SYSTEMS

# Preface I

Agricultural and rural modernization is integral to the overall success and high-quality of Chinese modernization. Throughout the process of advancing socialist modernization, issues concerning agriculture, rural areas, and farmers have always been a core priority for national development and people’s well-being, bearing directly on the realization of national rejuvenation and long-term social stability. A solid agricultural foundation, harmonious rural communities, and prosperous farmers are essential for the country's overall agenda to advance steadily and sustainably.

At present, China’s agriculture is undergoing profound historic transformation. On the demand side, rising incomes among urban and rural residents and sweeping shifts in dietary patterns have fueled growing demand for diversified, premium agricultural products, continuously driving the optimization and upgrading of agricultural supply chains. At the same time, the two-way flows and deep integration of urban and rural production factors have highlighted the multiple functions of agriculture, including ecological conservation, cultural heritage preservation, and agritourism, dramatically expanding the boundaries of the agricultural sector. On the technology front, a new wave of scientific and technological innovation, represented by digital technologies, AI, and modern bio-breeding, is rapidly permeating the agriculture, bringing about systemic changes in production organization and resource allocation. These far-reaching changes present not only unprecedented historic opportunities but also higher standards for agricultural modernization and the development of a strong agricultural nation.

However, we must remain a clear understanding about the challenges ahead. Domestically, China still relies heavily on international markets for a range of non-staple agricultural commodities. Imbalances in regional grain production and distribution, along with structural shortfalls in food self-sufficiency, remain prominent concerns. Meanwhile, the combined effects of intensifying climate change and the country’s vulnerability to frequent natural disasters continue to increase the exposure facing agricultural production. Internationally, profound shifts unseen in a century are accelerating, geopolitical tensions are intensifying, and multiple risks and challenges are becoming increasingly intertwined, posing severe strain on global agricultural stability. The COVID-19 outbreak in 2020 severely disrupted global supply chains; the 2022 Ukraine crisis prompted more than thirty countries to impose agricultural exports restrictions; and the 2026 conflict among the United States, Israel, and Iran has pushed up energy and fertilizer prices sharply, threatening global food security. These crises have laid bare the inherent fragility of global food security strategies.

The Outline of the 15th Five-Year Plan underscores a core principle: strengthen security through development and pursue development while ensuring security; reinforce bottom-line thinking; effectively prevent and defuse various risks; enhance economic and social resilience; and safeguard the new development paradigm with a new security framework. Economic resilience constitutes a core strategic foundation for major countries competing on the global stage. It serves not only as a stabilizing anchor against external shocks but also as a vital source of strategic confidence amid geopolitical competition. The resilience and security of industrial and supply chains, in turn, are the core carriers of economic resilience and are directly linked to national economic security and high-quality growth.

Against an increasingly complex and challenging domestic and international environment, enhancing the resilience of agricultural industrial chains and supply chains is not only a practical necessity for safeguarding food security but also an essential requirement for balancing development and security and transforming agriculture into a modern, large-scale industry.

The 2026 China and Global Food Policy Report, themed with Reframing Resilience for Strengthening Agrifood Systems, reflects a strong awareness of contemporary challenges and a forward-looking vision. Through the integrated use of data analysis, model simulations, and case studies, the report systematically presents the multiple risks and challenges facing China's agrifood systems across production, processing and distribution, and consumption. It proposes practical pathways to enhance resilience and provides an in-depth research into how fiscal, credit, and insurance instruments can support agrifood systems resilience. Upholding an interdisciplinary analytical framework, the report pairs a global perspective with grounded insights into China's national realities. Its findings and policy recommendations offer valuable references and decision-making support for government agencies, regulatory bodies, research institutions, and industry stakeholders alike. I am confident that the release of this report will further build consensus across all sectors, promote the transformation and upgrading of China's agrifood systems, strengthen its capacity to withstand various risks and shocks, and contribute Chinese wisdom and solutions to global efforts in building resilient agrifood systems.

**CHEN Xiwen**
Director, Committee on Agriculture and Rural Affairs,
13th National People's Congress of China

# Preface II

The world is undergoing profound changes unseen in a century, and the global agrifood systems are confronted with an increasing array of interwined risks and challenges. Geopolitical conflicts, more frequent extreme weather events, sweeping restructuring of international supply chains, slowing global economic growth, and rising inflationary pressures have created heightened uncertainty for agricultural production, food distribution, consumer welfare, and nutrition security. Persistent hunger and malnutrition worldwide further expose the fragility of agrifood systems. For China, although grain production has remained consistently high for many consecutive years and food security capacity has continued to improve, the tight balance between food supply and demand has not fundamentally resolved. Structural imbalances, market volatility and latent risks persist across agricultural production, supply chain operations, and nutrition security. Against this backdrop, it is imperative to better coordinate development and security priorities, accelerate the transformation of agrifood systems from an efficiency-oriented approach toward one that equally prioritizes security and resilience, strengthen resilience throughout the entire value chain, and better ensure the stable supplies of essential agricultural and food products and the nutrition well-being for all citizens.

It is in this context that the 2026 China and Global Food Policy Report is officially launched. Prepared by the Academy of Global Food Economics and Policy (AGFEP) at China Agricultural University under the leadership of Professor Fan Shenggen, in collaboration with partner institutions, this annual report series has long focused on major theoretical and practical issues surrounding agrifood systems transformation. Following previous editions examining agrifood system transformation in the post-pandemic era, agricultural support policy optimization, sustainable healthy diets, diversified food supply, and low-carbon transforamtion of agrifood systems, this year's report centers on Risks, Challenges, and Pathways for Building Resilient Agrifood Systems in an Era of Uncertainty. Taking a food system perspective, it provides an in-depth analysis of production volatility, supply chain resilience, nutrition security, and fiscal and financial support mechanisms. Drawing on multidisciplinary approaches, including input-output modeling, resilience indicator frameworks, household surveys, and case studies, the report systematically assesses the current state of agrifood systems and future risk response strategies. Its objective is to provide policymakers, industry practitioners, and researchers with comprehensive, forward-looking, and actionable insights. The report argues that future resilience-building efforts should focus on three pillars: establishing a production system characterized by risk preparedness, stable productivity, and green adaptation; creating efficient, reliable, and responsive resilient networks throughout supply chains; and developing consumer-side mechanisms that promote individual nutrition security, targeted interventions, and intergenerational equity. At the same time, fiscal and financial innovation should be advanced to foster a multi-stakeholder resilience framework supported by diverse policy instruments.

The consistent publication of this report series reflects China Agricultural University's enduring commitment to advancing agrifood systems transformation. For many years, the University has dedicated itself to serving national strategic priorities, aligning frontier agricultural science with the country's core development needs. It has continuously ramped up research and innovation in key areas such as food security, green agricultural development, and agrifood systems transformation, while actively promoting interdisciplinary collaboration, coordinated scientific research, and high-level talent cultivation. In recent years, the University has deepened its research in areas including biobreeding, agricultural production resilience, food supply chain security, and nutrition improvement, producing a range of outcomes with significant strategic value and policy impact. It has also played an active role as a high-level think tank, contributing intellectual support to national food security initiatives, the development of a robust agricultural sector, comprehensive rural revitalization, and global agricultural governance.

In addition to academic research, China Agricultural University has hosted three iterations of the World Agrifood Innovation Conference (WAFI), creating a high-level international platform for dialogue to address critical issues including global agrifood systems transformation, climate change mitigation, and agricultural technology innovations. By bringing together leaders from government, industry, academia, and research communities worldwide, the conference has catalyzed forward-looking consensus and tangible cooperations. These efforts not only demonstrate the University's sustained leadership in these fields but also underscore its commitment to serving national strategies and engaging deeply in global agricultural governance.

Looking ahead, China Agricultural University will continue to uphold its mission of serving national needs, advancing scientific frontiers, supporting socioeconomic development, and safeguarding public health. By further integrating basic research, applied research, and policy-oriented think tank studies, the University will continue to contribute to China's drive to build a strong agricultural nation and advance global sustainable development.

**CHEN Wei**
President, China Agricultural University

# Preface III

Global agriculture and food systems are currently undergoing profound transformation. Geopolitical conflicts keep evolving, extreme weather events are becoming more frequent, and global supply chains are rapidly shifting from an efficiency-only model toward one that prioritizes security and redundancy equally. Meanwhile, global food security remains a pressing challenge, with hunger and undernutrition yet to be fundamentally resolved. As a result, the vulnerabilities and systemic risks within agrifood systems have drawn increasing attention. In an era of heightened uncertainty, agrifood systems must move beyond reactive emergency response approaches and accelerate the transition toward a resilience-centric paradigm. Building an integrated capacity for resistance, rapid recovery, and adaptive transformation has become a strategic priority for global food governance.

Within China, strengthening the resilience of agrifood systems is equally significant. In recent years, the country's overall grain production capacity has expanded steadily, further consolidating the foundation for stable production and supply. Even so, the long-standing tight balance between food supply and demand has not been fundamentally changed, and structural bottlenecks remain persist. At the same time, disparities in production stability across agricultural products, inefficiencies in supply chain and distribution links, and uneven household nutrition security all indicate that China's agrifood systems still need stronger overall resilience to withstand multiple risks and shocks. Shifting from reactive emergency responses to proactive risk prevention, and from localized post-crisis recovery to system-wide resilience, has become a central challenge for agrifood systems transformation in the new era. It is also essential for safeguarding long-term food security and improving the nutrition well-being of the population.

To address these challenges, the 2026 China and Global Food Policy Report has been jointly released by the Academy of Global Food Economics and Policy (AGFEP) at China Agricultural University, led by Professor Shenggen Fan, in partnership with leading domestic and international research institutions. Adopting a holistic perspective, the report focuses on the risks, challenges, and resilience-building pathways for agrifood systems amid pervasive uncertainty. It examines the entire value chain, from production and intermediate supply chain links to consumption, and analyzes the transmission mechanisms and policy buffering effects of diverse shocks, including climate change, crop pests and diseases, livestock epidemics, and geopolitical conflicts.

The report highlights the importance of forward-looking and systemic approach to resilience building, highlighting the vital roles of technological innovation, policy optimization and coordinated fiscal and financial support. It puts forward a suite of policy recommendations: strengthening agricultural risk early-warning systems, enhancing resilient storage and logistics networks, and improving targeted household nutrition intervention mechanisms. These recommendations provide scientific guidance for advancing a high-quality and resilient transformation of agrifood systems.

The release of the 2026 report will further drive the evolution of agrifood systems toward greater efficiency, resilience, nutrition, security, and sustainability. It offers actionable insights for policymakers, researchers, and industry stakeholders alike, generating positive social impact and supporting both China and the global community in building safer and more resilient agrifood systems amid persistent global uncertainty.

**QIAN Keming**
Chief Research Fellow at the Chinese Academy of Agricultural Sciences
Former Vice Minister of Commerce of the People's Republic of China

# Preface IV

Global agrifood systems have entered a new era of intersecting risks and growing uncertainty. Geopolitical conflicts, extreme climate events, large-scale disease outbreaks, resource and environmental constraints, and supply chain disruptions are increasingly intertwined, profoundly reshaping food production, distribution, and nutrition outcomes worldwide. Agrifood systems are critical not only to national security but also to the daily well-being of billions of people. Their capacity to ensure stable food supplies, reasonable prices, and equitable access to balanced nutrition in the face of multiple shocks has become a key benchmark for measuring a nation's agricultural strength, governance capacity, and societal resilience.

In recent years, China has steadily enhanced its overall grain production capacity, continuously shoring up foundations of food security and expanding the supply of key agricultural products. These achievements have provided robust support for stable economic and social development. That said, we must recognize the enduring structural challenges facing China's agrifood systems. While staple grain supplies remain generally stable, output of cash crops, livestock, poultry, and aquatic products remains vulnerable to climate disasters, disease outbreaks, and market volatility. Although quantitative food security has been largely ensured, gaps remain in food quality, nutrition balance, and equitable access to nutrition for vulnerable populations. Moreover, weaknesses persist in storage and logistics, food processing and trade, retail distribution, and fiscal and financial support frameworks. The coordination and adaptive capacity of these sectors to navigate complex risks require further strengthening.

Building resilient agrifood systems is not merely about recovering from disasters or increasing emergency reserves, rather, it is a systemic undertaking that integrates proactive risk prevention, agile shock response and long-term structural transformation. Resilience requires early warning systems and full preparedness ahead of crises; sustained supply stablility and safeguard of core system functions during disruptions; and resolution of development bottlenecks, optimized supply structures, and improved overall system performance after shocks. In the context of China's national conditions, strengthening agrifood systems resilience requires not only safeguarding food security but also embracing a holistic food systems approach, advancing from quantity-oriented food security toward a framework that simultaneously ensures food quantity, quality, and nutrition while meeting the increasingly diverse and health-oriented dietary demands of the population.

Against this backdrop, the 2026 China and Global Food Policy Report, themed Reframing Resilience for Strengthening Agrifood Systems, carries significant practical relevance and policy value. Prepared by the Academy of Global Food Economics and Policy (AGFEP) at China Agricultural University under the leadership of Professor Fan Shenggen and in collaboration with partner institutions, the report draws on China's domestic experiences while examining global trends. It systematically analyzes core dimensions of agrifood systems resilience, existing vulnerabilities, and pathways for improvement across production, circulation, consumption, and institutional support systems. Beyond stable grain and key agricultural output and supply, the report addresses supply chain resilience, national nutrition security, and the enabling functions of fiscal and financial policies. Its problem-oriented analysis and targeted policy recommendations render it particularly an valuable reference for decision-makers.

The report finds that China's agricultural production remains relatively stable on national level, with grain production acting as a critical stabilizing force. However, supply volatility varies sharply across regions and product categories, but cash crops, livestock, poultry, and fisheries exhibit notable risk vulnerability. To address pressures stemming from climate change, pests and diseases, animal epidemics, and rising agricultural input costs, the report recommends establishing differentiated monitoring and early warning systems by region, commodity and hazard types, alongside continued investment in high-standard farmland, seed innovation, disease prevention and control systems, and agricultural risk management capacity.

The report also delivers incisive analysis of supply chain resilience. It argues that the shock resistance of agrifood systems depends not only on production capacity but also on the smooth functioning of storage and logistics, food processing, international trade, and retail distribution. Storage and logistics form the backbone of cross-regional food allocation and emergency supply; food processing extends supply chains and stabilizes nutrition availability; international trade mitigates supply gaps and diversifies market risks; and retail systems directly determine consumers' access to affordable, timely delivered foods. Enhancing resilience in these sectors requires maintaining operational efficiency with strengthening supply redundancies, backup channels, and emergency response capacities.

A distinctive feature of the report is its emphasis on nutrition resilience at the consumption stage. Food security is not solely a matter of aggregate supply; it is equally a question of equitable access to sufficient and balanced nutrition. In times of income instability, food price inflation, or supply disruptions, low-income households, elderly rural populations, women, children, and migrant communities are especially vulnerable to nutrition deprivation. The report argues that policy design should move beyond aggregate household indicators and instead identify nutrition vulnerabilities across population subgroups and within individual households. Nutrition well-being should be positioned as a central objective of agrifood systems resilience.

Fiscal and financial policies constitute another essential pillar of resilience building. Given the public-good nature of agrifood systems resilience, market forces alone cannot provide it effectively. The report systematically examines the roles of public investment, agricultural credit, agricultural insurance, supply chain finance, green finance, alongside diversified financing mechanisms in addressing infrastructure gaps, spreading operational risks, stabilizing market expectations, and facilitating system transformation. Looking ahead, it recommends enhancing the efficiency of public financial support, establishing robust risk-sharing mechanisms among governments, financial institutions, insurers, guarantors, and agribusinesses, and directing public resources toward key priorities such as stable food production, nutrition improvement, green transformation, and support for vulnerable populations.

Agriculture and food issues cannot be understood through the lens of individual sectors, commodities, or short-term supply-demand mismatch alone. They must be approached from the broader perspectives of national security, public health, rural revitalization, and the development of a strong agricultural nation. Strengthening agrifood systems resilience requires consolidating foundational capacities in farmland protection, seed innovation, and agricultural technology; addressing weaknesses in distribution, processing, consumption, and nutrition; and leveraging both government guidance and market-driven innovation. It also demands coordinated efforts from research institutions, industry organizations, and society at large. This report successfully captures and advances such a systemic analytical mindset.

Particularly noteworthy is that this edition of the China and Global Food Policy Report marks the sixth consecutive annual publication produced by Professor Fan Shenggen and his research team. Over the years, the team has focused on critical issues such as agrifood systems transformation in the post-covid era, agricultural support policy reform, healthy diets, green and low-carbon development, and resilience building. Grounded in China's realities yet informed by global perspectives, these reports integrate interdisciplinary research and policy simulation analysis to make important contributions to both academic research and policy formulation.

Looking ahead, as global uncertainties continue to evolve and China accelerates its agricultural modernization, building resilient agrifood systems will become increasingly important for safeguarding food security, improving nutrition well-being, and promoting high-quality development of food and nutrition systems. Only by strengthening foundational capacities, enhancing value chain coordination, prioritizing nutrition, and improving institutional support can China continuously upgrade its capacity to withstand shocks, recover rapidly, and adapt to change. In doing so, it can forge a uniquely Chinese pathway toward stable production, improved quality, balanced nutrition, and sustainable development. I hope this report will further build societal consensus, encourage coordinated action among stakeholders, and contribute valuable insights and policy recommendations to strengthen China's agrifood systems resilience, safeguard national food and nutrition security, advance the building of a strong agricultural nation and realize Chinese modernization.

**CHEN Mengshan**
Chairman, National Food and Nutrition Advisory Committee

# Reframing Resilience for Agrifood Systems Through Strategic Transformation: Key Findings and Policy Recommendations

**FAN Shenggen and XING Li**

Academy of Global Food Economics and Policy, China Agricultural University

The global agricultural and food systems (hereinafter referred to as the "agrifood systems") stand at a juncture of profound uncertainty. Escalating geopolitical tensions, intensifying climate extremes, and a fundamental paradigm shift in global supply chains, where security considerations have increasingly superseded efficiency objectives, are placing unprecedented strain on the system. This pressure is exacerbated by persistent stagflationary headwinds, subdued economic growth, and a stubbornly high global hunger burden affecting 673 million people. Moreover, the exponential advancement of digital and bio-technologies presents high potentials, but they also introduce complex risks and social and economic exclusions. Collectively, these convergent forces are reshaping socioeconomic trajectories while exposing deep-seated structural vulnerabilities within the global agrifood systems.

Against this volatile backdrop, Chinese agrifood systems have demonstrated remarkable resilience. Despite the structural reality of a persistently tight equilibrium between grain and demand, national grain production has remained stable at over 650 million metric tons for ten consecutive years. This achievement has not only solidified the foundation for holding the Chinese food bowl firmly in its own hands but also injected much-needed stability into the global landscape[1].

Addressing these dynamics requires a strategic pivot away from the traditional Efficiency-First emergency logic epitomized by the Just-in-Time model, toward a resilience paradigm that balances Efficiency with Strategic Redundancy, namely the Just-in-Case approach. By constructing a three-pronged capacity framework centered on Resistance, Recovery, and Transformation, and by optimizing resource allocation and institutional support across the entire agrifood continuum, policymakers can ensure sustained access for consumers, particularly vulnerable populations, to adequate, diverse, and nutritionally balanced diets in the face of systemic shocks.

As the latest installment in the China and Global Food Policy Report series, this annual report builds upon the research trajectory of the 2021-2025 editions. Previous iterations addressed critical issues such as agrifood systems transformation pathways for the post-covid era, the optimization of agricultural support policies, the improvement of sustainable and healthy dietary patterns, the diversification of food supply systems under the Big Food Concept, and low-carbon transformation of the agrifood systems[2]. This year's report continues to use a food system approach spanning production, intermediate links, and consumption. It examines the multifaceted risk challenges confronting agrifood systems and rethinks pathways to building resilience in this era of uncertainty.

Employing a multidisciplinary framework, and Computable General Equilibrium (CGE) models and resilience indicator systems, and through case studies integrating micro-surveys, macro-data, and fiscal and financial

[1] People's Daily Online. (2023, June 26). Quotes from Xi: Holding rice bowls firmly in our own hands. https://en.people.cn/n3/2023/0626/c90000-20035896.html.

[2] CHINA POLICY team,No. 1 document 'Big Food' concept - by https://chinapolicy.substack.com/p/no-1-document-big-food-concept.

instruments, the report systematically assesses the current operation dynamics. The aim is to provide government agencies, regulatory bodies, academia, and industry stakeholders with research support and decision-making references embodying systematic rigor, scientific validity, and forward-looking insight.

This report was jointly prepared by the Academy of Global Food Economics and Policy (AGFEP) at China Agricultural University (CAU), in collaboration with multiple key relevant institutions. Contributing institutions include the College of Economics and Management at CAU, the Institute of Agricultural Information at the Chinese Academy of Agricultural Sciences (CAAS), the College of Water Resources and Intelligent Engineering at CAU, the Institute of Food and Nutrition Development at the Ministry of Agriculture and Rural Affairs(MARA), the International Food Policy Research Institute (IFPRI), the China Academy for Rural Development at Zhejiang University, the Institute of Agricultural Economics and Information at the Guangdong Academy of Agricultural Sciences, Fuzhou University, and the School of Economics and Management at the Xinjiang Polytechnic Vocational University. The report also received support from the FAIRR Initiative, the World Resources Institute (WRI), the Food and Land Use Coalition (FOLU), and the Environmental Defense Fund (EDF).

The structure and research content of this report are outlined below:

Chapter 1: Theoretical and Research Framework. Reflecting on the evolving global and Chinese context, this chapter rethinks and redefines the resilience for agrifood systems in the era of polycrises and proposes holistic enhancement pathways from a whole-chain perspective.

Chapter 2: Production Resilience. This chapter quantitatively evaluates China's food production resilience across yield, nutrition, and prices. By simulating future risk shocks, it gauges the buffering effects of policy adaption measures, and recommends strategies for stabilizing the supply of staple and key agricultural products.

Chapter 3: Resilience of Intermediate Links. Analyzing nodes such as warehousing, logistics, processing, and trade, this chapter identifies structural constraints in building resilience for the midstream of agrifood systems. Using a resilience index, it maps current challenges and outlines key pathways to strengthen supply chain resilience.

Chapter 4: Individual Nutrition Resilience.Incorporating intra-household allocation mechanisms into the analysis of individual nutrition resilience, this chapter dissects a 4A (availability, accessibility, awareness and allocation) transmission pathways and associated challenges. It synthesizes domestic and international experiences to propose differentiated intervention strategies for household and individual resilience.

Chapter 5: Fiscal and Financial Support. This chapter elucidates the theoretical logic and functional roles of financial, fiscal, and insurance instruments, such as blended finance and insurance, in building resilience. It showcases multi-instrument collaborative innovations and distills actionable implementation plans.

Accordingly, the report presents the following Key Findings and Policy Recommendations.

## 1. Key Findings

### 1.1 Divergent Production Resilience in China: Macro Stability and Structural Imbalances

● National Agrifood Output Exhibits Stability but with Underlying Provincial Disparities and Non-staple Foods Volatility. While national agricultural output remains remarkably stable, fluctuating within a narrow 1 to 4 percent band, volatility amplifies significantly at the provincial level, ranging from 7 to 35 percent. Grain output varies by a mere 1.54 percent, underscoring its role as a ballast for stable supply. In contrast, non-grain categories exhibit far greater vulnerability, with year-on-year standard deviations for pork, oil crops, fruits, and aquatic products reaching 14.7, 20.2, 28.25, and 34.52 percent respectively.

● Dietary Energy Stability Masks Lurking Macronutrient Volatility in Nutrients Supply. While energy and carbohydrate supplies have maintained smooth trajectories, proteins and fat supplies exhibit relatively pronounced fluctuations. Exogenous shocks such as the COVID-19 pandemic exacerbated volatility after 2020, and no persistent downward trend has emerged overall.

● Grain Prices Remain Stable but Volatility in Animal Products and Cash Crops Continues. Grain prices have remained largely stable owing to policy interventions, whereas animal product prices exhibit drastic volatility, with peak year-on-year fluctuation in pork prices reaching 55.7 percent. Similarly, the price volatility of cash crops significantly exceeds that of staple grains, starkly revealing the structural imbalance inherent in the production resilience of the agrifood systems.

### 1.2 Rapidly Evolving Resilience of Intermediate Links: From Accumulation and Enhancement to Structural Consolidation

● Low Resilience Phase (2013-2018). During this period, the resilience index for intermediate links fluctuated within a narrow band of 0.45 to 0.52, indicating a uniformly weak profile. This stemmed primarily from foundational deficits in cold storage and freight capabilities, compounded by elevated import exposure.

● Enhancement Phase (2018-2022). The index surged from 0.48 to 0.63, propelled by the rapid expansion of warehousing, logistics, digital retail, and emergency response systems. This acceleration was driven by responding to the exigencies of the COVID-19 pandemic, and sustained public investment in food security.

● Structural Consolidation Phase (2022-2024). The index fluctuated within a tight range of 0.68 to 0.70, signaling a structural consolidation. The marginal pullback observed in 2024 likely reflects the dual challenges of diminishing marginal returns on policy interventions and mounting geopolitical risk pressures.

### 1.3 Nutrition Resilience Divide:  Intra-Household Gaps and the Policy-Outcome Disconnect

● Individual Nutrition Resilience Remains the Blind Spot of Household-Centric Metrics. Traditional indicators of nutrition resilience, such as the Household Dietary Diversity Score (HDDS), implicitly assume equitable resources distribution among household members. In reality, intra-household allocation reveals far greater complexity, marked by persistent inter-generational and gender disparities. Data indicates that among low- and middle-income families, the elderly aged 75 and above and women exhibit notably lower Dietary Diversity Scores (DDS). This inequity is particularly acute in rural households with left-behind or solitary elderly members.

● A Decoupling of Well-Established Institutions and Lagging Policies. China has established distinct institutional strengths in basic security and emergency response. During major crises such as the COVID-19 pandemic, the government demonstrated institutional efficacy and coordinated resilience through efficient resource mobilization and targeted policy deployment. However, the policy focus lags behind the evolving nature of risks. Crucially, the intra-household allocation mecahnism, a critical mediator linking household resources to individual nutrition outcomes, has yet to be prioritized in policy design.

### 1.4 Simulations Scenarios Uncover Potential Perfect-Storm Dynamics and Systemic Vulnerability

● Climate Change Scenario Reveals Systemic Shocks to China's Agrifood production. These shocks trigger cascading economic disruptions and nutrition losses. Output of staple grains, fruits and vegetables, and livestock and aquatic products is projected to decline by 3.5 to 8 percent, 0.8 to 1.5 percent, and 1 to 3 percent, respectively. Reduced supply triggers significant price divergence: grain prices surge by 8 to 26 percent for rice and wheat, and 17 to 34 percent for corn, while meat prices rise by 2 to 4 percent. Consequently, grain imports are expected to increase by 3.4 to 6 percent. The shock propagates along the industrial chain, leading to an approximate 1 percent contraction in overall GDP, with agricultural GDP dropping by 1.2 to 2.6 percent, and output in food processing and the hospitality and catering sectors sliding by about 2 percent. Climate change also curtails the availability of macronutrients, including energy, protein and fat, by roughly 2 to 3 percent.

● Pest and Disease Outbreaks Trigger Localized Supply Contractions and Moderate Macroeconomic Spillover. Grain and horticultural outputs fall by 0.2 to 5 percent and 0.16 to 4 percent, respectively. Price increases of 1 to 12 percent for grain and 0.5 to 11 percent for vegetables remain milder than those under the climate scenario, with grain imports rising by 0 to 2 percent. Rising input costs amid uncertainty suppress consumer demand and output in agriculture, food processing, and hospitality, weighing on overall GDP. Pest outbreaks reduce energy supply by 1 to 2 percent, and curb protein and fat supplies by 2 to 3 percent and 3 to 5 percent, respectively.

● Animal Disease Scenario Leads to Concentrated Supply Contraction and Market Turbulence, with Macroeconomic Impacts Largely Contained. Output of livestock and aquatic products decreases by 0.12 to 3 percent and 0.2 to 5 percent, accompanied by significant price hikes of 0.2 to 7 percent. Domestic supply gaps lead to a marginal increase in meat imports, with a median rise of 0.2 percent. While the macro-level impact on overall GDP is limited, the food industry and catering sector suffer notable negative effects. Animal diseases cause protein and fat supplies to drop by 2 to 3 percent, alongside a slight dip in energy supply.

● Geopolitical Conflict Elevates Global Agrifood Costs from Hormuz Disruptions, and Domestic Production Impacts Remain Contained. This is primarily because China's fertilizer and pesticide industries are dominated by domestic production and sales, insulating them from international price volatility. Fluctuations in agrifood output and prices are relatively mild , ranging from 0.02 to 0.2 percent, import volumes remain stable and the impact on both the agrifood system and the national economy is constrained. Effects on nutrient supply are also minimal, staying within a 1 percent threshold.

● Intertwined Crises Scenario Delivers a Systemic Blow to China's Agrifood Systems, Constituting a Potential Perfect Storm. Grain output falls by 4 to 14 percent, fruits and vegetables by 1 to 7 percent, and livestock and aquatic products by 1.5 to 10 percent. Prices climb sharply: grain by 13 to 47 percent, vegetables and fruits by 0 to10 percent, and animal products by 2 to 14 percent. Grain imports rise by 3 to 8 percent. Due to cost escalations, the GDP of agriculture, food processing, and services all decline by 5 to 6 percent, dragging down overall GDP by approximately 2 percent. The impact on nutrients supplys is also severe, with dietary energy, protein, and fat availability dropping by 5 to 10 percent.

● External Shocks Erode Nutrition Resilience Primarily Through the Cascade Effect of Reduced Affordability. This chain reaction follows a clear sequence: income decline leads to reduced food expenditure, which triggers downgraded nutrition consumption. This is exacerbated by ineffective substitution due to a lack of nutrition knowledge, resulting in disproportionate nutrition loss among vulnerable household members. Such shock-triggered chain reactions manifest most completely and typically in vulnerable households, including low-income families, rural residents, and migrant populations.

## 1.5 Resilience Building Effectively Mitigates External Shocks to the Agrifood Systems

● Simulation Results Confirm that Resilience Measures can Significantly Mitigate the Impact of External Shocks. Traditional emergency management focused solely on bouncing back, or restoration, proves inadequate for addressing irreversible compound risks. Agrifood systems resilience must pivot toward bouncing forward, shifting from passive post-shock recovery to leveraging shocks as catalysts for structural adjustment, thereby achieving synergy among resistance, recovery, and transformation.

● Production-Side Interventions Prove Effective. Integrating high-standard farmland construction with stress-resistant breeding could narrow grain output declines under climate change scenarios from 3.5 to 8 percent down to 0.5 to 3 percent, while curbing price surges to 2 to 12 percent. Advanced pest control technologies could reduce crop losses from 0.2 to 5 percent down to 0.1 to 2 percent, lessening import dependency. Furthermore, vaccine R&D and mandatory immunization could limit output drops in livestock and aquatic products to within 0.6 percent, preventing drastic price fluctuations in pork and other commodities. Although comprehensive measures cannot fully offset systemic shocks, they can narrow the overall GDP decline from 2 to 1 percent and keep losses in dietary energy, protein, and fat supplies below 2 percent, significantly bolstering the nutrition security resilience.

● Enhanced Intermediate Links Efficiency Underpins Overall Resilience. China's agricultural logistics infrastructure is shifting from simply expanding storage expansion toward a dual focus on circulation efficiency and post-harvest losses reduction, laying a crucial foundation for systemic resilience. Regarding grain distribution, a cross-regional circulation pattern characterized by the North-to-South and Central-to-West Grain Transportation[3] has taken shape. Railways, waterways, and highways account for approximately 50, 40, and 10 percent of inter-provincial transport volume respectively, reflecting a maturing multimodal transport system. Concurrently, national grain storage capacity continues to expand, the storage structure is being optimized, and the coverage of emergency reserve, transport, and distribution networks has expanded significantly.

● China's Multi-Tiered Protection Framework Strengthens Nutrition Resilience. China's framework is anchored by social assistance as the foundation, food security strategies as the backbone, and targeted nutrition interventions as supplements. According to National Development and Reform Commission (NDRC), in response to the COVID-19 pandemic in 2020, the government issued CNY 19.09 billion in temporary price subsidies, benefiting 310 million person-times. By the end of 2022, a nationwide grain emergency network covering both urban and rural areas had been established, with emergency processing capacity sufficient to meet the nation's basic needs for approximately two days.

● Financial and Fiscal Support Delivers Tangible Resilience Dividends. The agrifood systems exhibit significant public goods attributes. Given the market's insufficient provision, a collaborative framework is required, characterized by fiscal funds providing steering, financial instruments offering empowering, and social capital participating. China has preliminarily formed a multi-tiered support system: by the end of 2025, the outstanding agriculture-related loans reached CNY 53.6 trillion, and agricultural insurance premiums totaled CNY 155.5 billion, cementing China's position as the world's largest agricultural insurance market. Innovative instruments such as rural revitalization bonds, green credit, and supply chain finance continue to emerge, while pilot programs for models like Insurance Plus Futures and blended finance have demonstrated tangible results.

## 1.6 However, Short-Term Relief Measures Can Undermine Long-Term Agrifood Systems Resilience

● Agrifood Systems Resilience Entail Dynamic Evolution Through Three Capabilities, No Reversion to the Pre-Shock Status Quo. The system evolves dynamically by the progressive layering, mutual reinforcement, and synergistic development of resistance, recovery, and transformation. Upon impact, the agrifood system first leverages resistance to cushion the shock and reach its bottom. It then deploys recovery to restore functionality. Ultimately, structural transformation enables the system to bounce forward, transitioning toward efficient and sustainable long-term resilience.

● Emergency Interventions Entail Significant Long-Term Risks Despite Their Short-Term Necessity. Research indicates that amid emergencies such as food crises, pandemics, or geopolitical conflicts, governments often resort to stop-gap measures, including subsidies, price supports, and trade protectionism. While these measures rapidly block crisis transmission, stabilize market expectations, and protect vulnerable groups, they carry significant risks. Failure to exit such measures timely or poor design breeds path dependency and market distortions, inflicting deep-seated damage on the long-term industrial structural optimization and competitiveness cultivation.

[3] Research Review and Development Trend Analysis of Grain Multimodal Transport with a Special Emphasis Upon China, https://agris.fao.org/search/en/records/69b95fef1acdc0f2bc7fd958.

## 2. Policy Recommendations

### 2.1 Production Side: Building a Resilience System for Front-Loaded Risk, Stabilized Capacity, and Green Adaptation

● Strengthening Ex-Ante Prevention. Dismantle data silos across meteorology, plant protection, water resources, credit, and insurance to establish an integrated, categorized early warning system for regions, product types, and disaster types. Prioritize resources allocation to major grain-producing areas, medium- and low-yield farmland, and climate risk-exposed regions. Accelerate the construction of high-standard farmland, irrigation and drainage facilities, and pest monitoring stations, while refining emergency reserve and deployment mechanisms for critical inputs such as seeds, fertilizers, feed, and vaccines, to ensure these resources are accessible, rapidly deployable, and readily usable when crises strike.

● Facilitating Post-Disaster Recovery. Establish robust mechanisms for replanting, cross-regional machinery dispatch, and production-marketing coordination. Enhance mandatory immunization, non-hazardous disposal, culling subsidies, and restocking support for livestock. Improve policy synergy among agricultural catastrophe insurance, agricultural insurance, disaster relief, and credit support, while establishing green channels to improve claims settlement targeting smallholders, small-to-medium farms, and remote areas.

● Promoting Resilience Transformation. Concentrate R&D on crop varieties resistant to droughts, waterlogging, pests, and diseases, as well as high-nutrition varieties,bolstered by germplasm protection. Promote green pest control, and intelligent monitoring to gradually replace high-intensity chemical use and reduce non-point source pollution. Link subsidies, credit, and insurance directly to water and fertilizer reduction, eco-friendly farming, and diversification. An Agricultural Resilience Development Fund should be established. By leveraging policy loans, special bonds, and technology vouchers, the goverment can guide private capital to participate in upgrading agrifood systems resilience.

### 2.2 Intermediate Links: Establishing a Resilient Network for Seamless Flow, Ample Capacity, and Highly Responsive Operations

● Weaving Dual Network of Domestic Nodes and International Corridors. Bolster the multi-tiered reserve system of central, regional, and community hubs, prioritizing breakthroughs in deploying fresh and short-shelf-life foods. Layout overseas warehousing and transshipment facilities in major grain-producing regions and at critical shipping nodes to mitigate chokepoints risks associated with key hubs like the Strait of Malacca and the Strait of Hormuz. Develop intelligent multimodal dispatch platforms, and automate alternative routing to ensure the cross-regional allocation of grain, oil, and fresh products.

● Enhancing Dual Capabilities for Peacetime and Emergency Response. Guide enterprises to maintain dual inventories and adopt modular, digital lines to achieve seamless conversion to emergency food production. Popularize nutrition fortification technologies, e.g., fortified flour and edible oils, to prevent micronutrient degradation during emergencies. Construct a farm-to-table traceability system using transparent data to preempt consumer panic.

● Constructing Diversified Risk Avoidance and Rules-Based Safeguards. Diversify import sources, focusing on soybeans, oil crops, supported by a red-yellow-blue early warning mechanism. Leverage the Belt and Road Initiative to bind the supply capacity of major trading partners through technology transfer and cooperation. Advocate for green trade channels under extreme scenarios by shaping multilateral rules.

● Opening Last-Mile Connectivity and Special Safeguards. Regulate platform algorithms to prohibit big data-enabled price gouging while safeguarding traditional outlets like farmers' markets. Tackle last-mile gaps via a Platform plus Community plus Volunteers convertible distribution mechanism. Establish a normalized food voucher system for low-income groups to guarantee nutrition access during crises.

● Strengthening the Shock-Absorbing Function of Fiscal-Financial Linkages. Jointly mobilize governments, banks, insurers, and guarantee agencies for resilience financing and risk-sharing. Leverage fiscal funds to crowd-in private capital to support storage and processing entities via financing and risk transfer solutions. Integrate AI, IoT, and blockchain to secure the agrifood systems.

### 2.3 Consumption Side: Improving Resilience for Nutrition Security, Targeted Intervention, and Inter-generational Equity

● Strengthening a Nutrition-Oriented Social Support System. Redirect social security from cash subsidies to nutrition in-kind transfers. Introduce designated-use nutrition vouchers to guide low-income households toward nutrient-dense foods like fruits, vegetables, dairy, and soybean products. Optimize targeting by channeling transfers directly to primary caregivers, typically women. A three-tiered government-community-household emergency food reserve system must stockpile shelf-stable, high-protein foods and micronutrients at the community level to protect vulnerable groups, including the elderly living alone and low-income, multi-child families.

● Enhancing Dynamic Buffering Capacity Through Supply-Demand Alignment. Implement the Big Food concept to steer the agricultural supply toward nutrition diversification. Integrate dietary and nutrition education into the public health system, offering food education curricula for children and chronic disease-linked dietary guidance for middle-aged and elderly individuals to improve household food resource efficiency. Regulate the platform economy, support short-chain models such as urban agriculture, community group buying, and preserve offline channels for the elderly and less-educated groups to bridge the digital divide.

● Eliminating Structural Barriers and Bolstering Individual Nutrition Resilience. Extend the Nutrition Improvement Program for Rural Compulsory Education Students to cover preschool education. Rectify the empty calories dilemma (lacking nutrition value) in schools serving concentrated left-behind children to block the intergenerational transmission of poverty. Embed gender-priority mechanisms into employment training and entrepreneurial guaranteed loans to enhance women's household decision-making power and nutrition access. Include community meal assistance for the elderly in basic public services, offering property tax reductions and fiscal subsidies to support central kitchens and home delivery, thereby compensating for the degradation of family care functions. Integrate data from health, agriculture, civil affairs, and statistics departments to build a household nutrition resilience monitoring system, dynamically identifying vulnerable groups and high-risk areas to achieve precise and inclusive policy delivery.

### 2.4 Fiscal-Financial Synergy: Moving Toward Empowerment and Sustainability-Oriented Innovation System

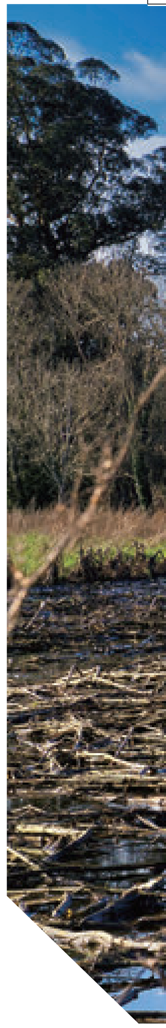
● Strengthening the Steering Role of Fiscal Expenditure. Central government transfer payments earmarked for agrifood resilience should prioritize infrastructure in central and western regions, smallholders capacity building, and nutrition-sensitive projects. Optimizing the subsidy structure requires shifting direct support toward resilience-linked models, such as catastrophe coverage, production insurance, and green production incentives. An Agricultural Resilience Development Fund should be set up to use guarantees, risk compensation, and rewards-in-lieu-of-subsidies wold effectively crowed in private capital.

● Innovating Financial and Insurance Application Scenarios. Advancing supply chain finance enables warehousing, processing, and logistics enterprises to utilize warehouse receipt pledges, order financing, and leasing to alleviate MSMEs constraints. Aligning climate-smart agriculture, digital supply chains, and ecological restoration with green bonds and credit facilities green finance support, while scaling pilot thematic bonds for agrifood resilience. Expanding integrated insurance-service pilots remains critical to incorporating catastrophe and weather index insurance into central fiscal subsidies.

● Empowering Stakeholders and Fostering Endogenous Growth. Fiscal and financial support must pivot from short-term relief to long-term empowerment, shifting focus from price interventions to a diversified architecture of direct income subsidies, full-chain insurance, and resilience financing. Crucially, clear sunset clauses and exit mechanisms are required to preempt protectionist path dependency and safeguard sustainable development.

> Confronting an age of interwoven risks and heightened uncertainty, agrifood systems resilience has transcended beyond technical fixes and reactive mitigation to emerge as a core strategic imperative. This calls for a fundamental paradigm shift, moving beyond passive mitigation to proactive stewardship, and departing from an exclusive pursuit of efficiency to a balanced framework integrating efficiency with safety redundancy. Only through such a systemic transformation can all stakeholders architect a resilient system capable of safeguarding food security, nutrition well-being, and socioeconomic stability.

## Chapter 1



# Rethinking and Restructuring: Theoretical Implications and Evolutionary Logic of Agrifood System Resilience

**CHEN Yuquan[1], WANG Ziwen[1], XING Li[1], YANG Yuying[2], LIU Shiting[1], MENG Ting[1], and FAN Shenggen[1]**

1. Academy of Global Food Economics and Policy, China Agricultural University
2. Agricultural Information Institute, Chinese Academy of Agricultural Sciences

## Key Findings

● Contemporary agrifood systems are confronted with multiple overlapping risks and growing uncertainties. Geopolitical conflicts, extreme weather events, major pandemics and resource-environmental constraints are intertwined. Risks have taken on new characteristics including escalating intensity, rising frequency, structural coupling and amplified spillover effects. The conventional governance philosophy focused on restoring pre-crisis normalcy shows prominent limitations, calling for a new paradigm shift centered on resilience.

● The core of building a resilient agrifood systems lies not simply in returning to the original state, but in enabling the system to achieve forward transformation after shocks. Resilience of the agrifood systems refers to the capacity of the system to continuously safeguard nutrition security, sustain livelihood stability and optimize its structure amid uncertainties. Its development shall follow the principles of sustainable development, diversified security, holistic integration and risk adaptation, with the ultimate goal of nutrition and public health.

● China's agrifood systems have established a certain foundation for resilience across its full industrial value chain, yet notable imbalances and vulnerable nodes persist throughout all segments. The production end is under mounting pressure from climate change and resource constraints; the intermediate links face risks concerning the stability of logistics, trade and supply chains continuity; while the consumption side is challenged by issues such as individual nutrition resilience. Integrated advancement is therefore required from a full-industry-chain, cross-departmental and long-term perspective.

## Policy Recommendations

- Re-examine the framework for building resilient agrifood systems and reshape the governance paradigm from the perspective of integrated multi-risk management. Incorporate heterogeneous risks including climate change, market fluctuations, geopolitical tensions and public health hazards into a unified monitoring system to break the constraints of siloed risk governance. Integrate risk identification and proactive prevention into the every stage of governance process, upgrading risk management from a remedial measure to a core governance principle. This will shift the agrifood systems from an efficiency-oriented model toward a new paradigm that balances efficiency and security.
- Prioritize resilience capacity building to facilitate the agrifood systems' evolution toward a superior steady state amid shocks. Coordinate the green transition at the production end, the upgrading of supply chains, consumer nutrition improvement and innovation of financial instruments. Embed the capacities of resistance, recovery and transformation into all industrial links, so that external shocks can serve as catalysts for the system's structural advancement.
- Target critical vulnerable links of the system and prioritize resilience of intermediate sectors and trade. Improve multi-level emergency grain and food reserve alongside rapid deployment mechanisms, develop flexible production lines for food processing, and diversify import supply sources for strategic food commodities. Accelerate the construction of a full-chain digital early warning system to effectively prevent localized disruptions from evolving into cascading systemic crises.
- Focus on the goal of nutrition and health, and establish a long-term support mechanism for vulnerable groups guided by the Big Food Concept. Bring low-income populations, children, the elderly and migrant groups into the long-term security framework. Develop community food banks and improve equitable distribution mechanisms to fundamentally shift governance from ad hoc relief to regular safety nets, and ensure equitable and accessible nutrition for all.

## 1.1 Introduction

By the mid-2020s, while humanity has achieved unprecedented material prosperity and technological advancement, the world has entered into a period of drastic turbulence driven by intertwined geopolitical frictions, climate crises and technological revolutions, with uncertainty emerging as a defining feature of the global risk landscape. According to the Global Risks Report 2026 released by the World Economic Forum, over 90% of experts anticipate sustained global economic volatility over the next two years and the next decade, with geopolitical confrontations and extreme weather events identified as the primary triggers. Against this backdrop, China's 15th Five-Year Plan emphasizes the need to coordinate development and security, and to strengthen the resilience of the economy and society. This indicates that enhancing resilience against multiple risks has become a strategic priority for China at present and in the foreseeable future.

Amid the resonance of global risks, the agrifood system is suffering a triple blow from geopolitical conflicts, extreme climate and volatile prices of agricultural inputs. Coupled with rising trade protectionism and supply chain fragmentation, these factors have severely undermined global food distribution capacity, triggering food price inflation and deteriorating nutrition conditions. Although short-term emergency policies adopted by some countries, such as large-scale subsidies and marginal land reclamation, have mitigated immediate risks, they have aggravated resource depletion and ecological degradation, resulting in long-term policy dilemmas. In 2024, approximately 673 million people worldwide suffered from hunger, with around 2.3 billion people experiencing food insecurity. These figures not only reveal inherent structural imbalances within the global agrifood systems, but also markedly increase its vulnerability to external shocks (FAO et al., 2025), leading to a continuous deterioration of food security.

China has maintained a solid foundation for food security, yet its domestic agrifood systems still faces structural challenges and impacts from multiple risks. On the production side, major grain-producing regions including the Yangtze River Basin and the Huang-Huai-Hai Plain have frequently endured extreme heat, floods and droughts in recent years, posing unprecedented threats to the stability of agricultural production and food supply. For intermediate links, climate change, public health crises and geopolitical conflicts are profoundly reshaping the supply chain ecosystem. Meanwhile, the consumption end is confronted with the dual challenges of hidden hunger and nutrition excess. As a stabilizer and cornerstone of the economy and society, a lack of resilience in the agrifood systems will allow risks to spill over into broader sectors and give rise to secondary systemic hazards.

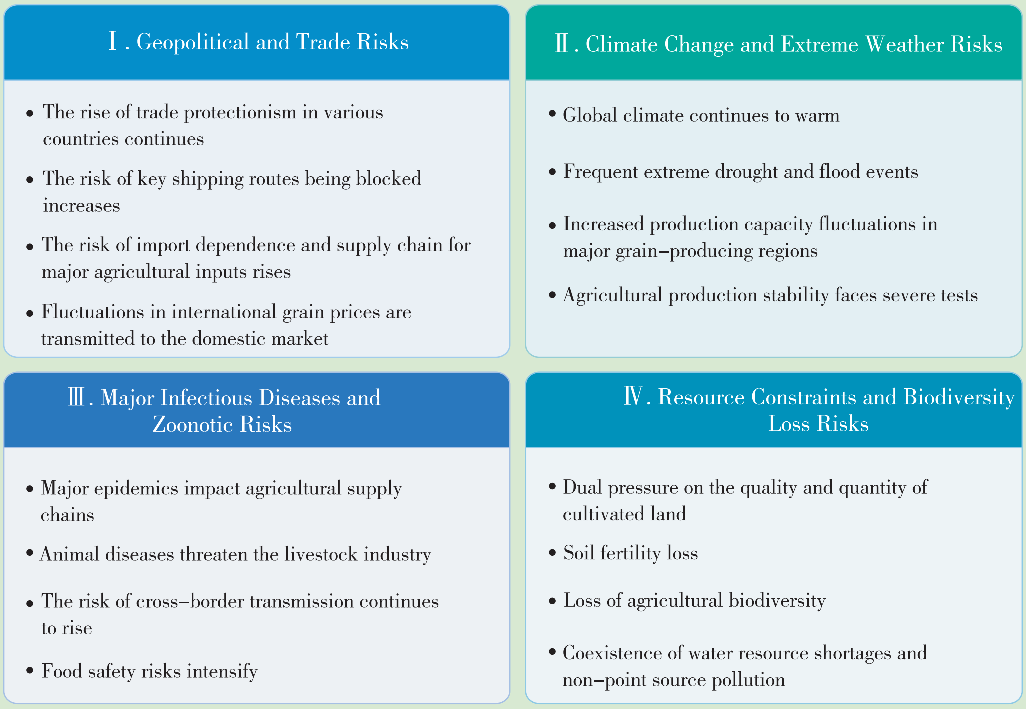
Given the growing complexity of external risks and inherent vulnerabilities of the system, it is imperative to break away from conventional perceptions and establish a new paradigm for the resilient transformation of the agrifood systems. Resilience building differs from passive response and temporary remediation. Rather than merely restoring the system to its pre-shock state, it aims to foster endogenous capabilities for stable operation, dynamic adaptation and proactive upgrading amid uncertainties through three core pathways: resistance, recovery and transformation. Current national initiatives to consolidate the foundation of food security in an all-round manner, implement the Big Food Concept and advance the green transition of agriculture all embody policy arrangements for agrifood resilience development. Food security necessitates sufficient supply buffers and risk resistance capacity; the Big Food Concept drives the shift of food supply from quantity orientation to quality improvement; and the green and low-carbon transition fundamentally enhances the climate resilience of the agrifood systems. Accordingly, advancing resilience building represents the systematic integration and in-depth implementation of national strategies.

From a full industrial chain perspective, this report innovatively systematically sorts out the resilience status, risk exposures and action pathways across all segments of the current agrifood systems. It also integrates fiscal and financial policy tools to expand financing channels for resilience development, improve risk-sharing mechanisms and empower systemic transformation, so as to deliver practical solutions for building a more resilient agrifood systems in China.

## 1.2 Major Risks Facing Global and China's Agrifood Systems

Currently, the risks confronting the global agrifood system have reached unprecedented levels in both intensity and complexity. Accurately identifying the nature, transmission paths and potential impacts of these risks serves as a fundamental prerequisite for formulating forward-looking response strategies (Figure 1-1).

**Figure 1-1 Major Risks and Challenges Facing the Global and Chinese Agrifood Systems**




**Source:** Authors' compilation.

### 1.2.1 Geopolitical and Trade Risks

Geopolitical tensions and trade restrictions are increasingly becoming major external disturbances to the stability of global agrifood systems. Since the outbreak of the Russia-Ukraine conflict in 2022, supply chain disruptions across the Black Sea region, a pivotal global granary and key fertilizer export corridor, have driven up international prices of fertilizers and energy sharply. The FAO Food Price Index hit 159.3 points in the same year, marking the highest level on record since data compilation began in 1990. Amid market turbulence, numerous countries imposed export restrictions out of concerns over domestic food security. According to statistics from the International Food Policy Research Institute (IFPRI), 34 countries worldwide introduced 98 trade restrictive measures on food and fertilizers in 2022, including export bans, additional export duties and mandatory licensing requirements (Glauber et al., 2022).

Against the backdrop of the suspended WTO Dispute Settlement Mechanism and the absence of effective multilateral coordination and governance, food and agricultural production inputs have increasingly been weaponized in geopolitical games. The weaponization of trade policies continues to undermine the stability and equity of the global agrifood systems.

For China, import sources of agricultural and food products are highly concentrated, and key commodities such as soybeans and corn rely heavily on a small number of trading partners. This makes the domestic food security system vulnerable to spillover effects from global geopolitical conflicts and trade frictions. For instance, the Strait of Hormuz handles approximately 20 percent of global oil trade. A prolonged escalation of tensions in the Middle East would trigger oil price shocks that propagate rapidly along the chain of energy – fertilizers – agricultural inputs. It is evident that the impacts of geopolitical risks on China's agrifood systems extend far beyond direct agricultural trade disruption, featuring pronounced chained transmission and amplification effects.

### 1.2.2 Climate Change and Extreme Weather Risks

Extreme weather events are eroding the foundation of agricultural production across the globe and in China with unprecedented intensity and frequency. Between 1991 to 2021, economic losses in global crop and livestock sectors caused by climat-related disasters totaled USD3.8 trillion, equivalent to an annual average of 5 percent of the global total agricultural output value on (FAO, 2023). As a region highly sensitive and vulnerable to global climate change, China faces particularly severe pressures. Between 1961 and 2023, the national annual average surface temperature rose by 0.30℃ per decade, exceeding the global average. Annual precipitation has increased overall, accompanied by intensified extreme rainfall; the number of days with torrential rain across meteorological stations rose by 4.1 percent per decade (National Climate Center, 2024). Meanwhile, heatwave events have become more frequent, intensive and prolonged.

Disaster statistics in recent years reveal that shocks from extreme climate have evolved from occasional incidents into a persistent pressure on China's agriculture. In 2025, the total affected area of crops nationwide reached 6,069.4 thousand hectares, with direct economic losses amounting to CNY241.6 billion (Office of the National Committee for Disaster Prevention, Mitigation and Relief & Ministry of Emergency Management, 2026). Henan Province experienced an abrupt alternation between a drought and a flood. Persistent low precipitation and high temperatures in spring and summer led to severe meteorological drought in some counties and cities, reducing summer grain output by approximately 357,000 metric tons (Rural Survey Department, National Bureau of Statistics of China, 2025). The region was then hit by persistent rainy weather in autumn. Since September, its average precipitation was 2.7 times the historical average, with the number of rainy days hitting a record high for the corresponding period since 1961. Excess soil moisture and field waterlogging hampered farm machinery operation, creating major obstacles to the harvesting, drying and post-harvest land preparation for winter wheat sowing. Pre-harvest sprouting and mold contamination occurred in major corn-producing areas (Xinhua News Agency, 2025). These trends indicate that extreme climate impacts have become a new normal for China's agrifood systems, systematically undermining the stability of food production.

### 1.2.3 Risks of Major Infectious Diseases and Zoonoses

Major infectious diseases and zoonoses are spreading from the public health domain into the food supply chain, emerging as new threats to agrifood system stability. The World Health Organization (WHO) and the U.S. Centers for Disease Control and Prevention (CDC) estimate that approximately 75% of emerging infectious diseases are zoonotic, ranging from HIV and Ebola to salmonellosis, with pandemic potential. In recent years, such risks have risen markedly. The World Organisation for Animal Health (WOAH) World Animal Health Situation 2025 confirms that the number of major cross-border animal disease notifications via its World Animal Health Information System (WAHIS) in 2024 reached an all-time high (WOAH, 2025). These outbreaks not only cause mass livestock deaths and production disruptions but also trigger cross-industry, cross-border shocks through trade restrictions, consumer panic, and supply chain breakdowns.

Major infectious diseases represent the most widespread risk with the longest transmission chains. The COVID-19 outbreak emerged in late 2019 and developed into a global pandemic in 2020, severely disrupting agricultural production, logistics and markets worldwide, and causing supply chain disruptions, labor shortages and food price surges. In the early stages of China's COVID-19 outbreak, control measures also affected food supply chains: vegetable and fruit shipments from producing areas were restricted, depressing farmgate prices. Urban consumption hubs faced temporary supply shortages, especially for cold-chain products. Zoonotic impacts are equally severe. The Asian Development Bank estimates that African swine fever caused direct losses of USD 55–130 billion to China and neighboring countries, including USD 28–46 billion in initial outbreak and culling losses, USD 4–7 billion in restocking costs, and USD 23–77 billion in income losses (ADB, 2020). In the United States, highly pathogenic avian influenza (HPAI) outbreaks persisted from 2022 to 2025, leading to the culling of over 150 million poultry birds. The resulting egg supply deficit drove a 36.8% year-on-year surge in egg prices, disrupting household food consumption and raw material supplies for food manufacturing (Xinhua News Agency, 2025). These cases show that infectious-disease risks can affect agrifood systems through both supply-chain disruption and direct losses in animal production.

### 1.2.4 Resource Constraints and Biodiversity Loss Risks

Land degradation, water scarcity and biodiversity loss are systematically eroding the long-term foundation of global food production, acting as critical slow-onset variables that shape agrifood system resilience. Currently, approximately 33% of global soils are moderately or severely degraded, causing annual cereal yield losses of around 7.6 million metric tons. Roughly 733 million people live in countries facing severe water stress. As climate uncertainty intensifies and populations grow, water competition between agriculture and other sectors will escalate, increasing the likelihood of regional food production pressures and resource-related risks (FAO, 2021). China also confronts severe land and water challenges: desertified land covers 2.5737 million km², accounting for 26.81% of total land area, while sandy land spans 1.6878 million km², accounting for 17.58% (Ministry of Ecology and Environment, 2025). The national arable soil exceedance rate for pollutants is 19.4%, and an estimated 12 million tons of grain are contaminated by heavy metals annually (Institute of Applied Ecology, CAS, 2019).

Biodiversity loss poses another major threat to agrifood systems. Currently, about 75% of global food supply depends on just 12 plant and 5 animal species, while over 75% of crop genetic diversity has been lost over the past century (The Royal Society, 2021). In agrifood ecosystems, biodiversity loss manifests not only in sharply reduced crop and livestock genetic diversity, but also in systematic declines of non-crop species, such as weeds and hedgerows, as well as pollinators, natural enemies and beneficial soil microbial communities. More than 75% of the world's 87 major food crops rely partly or heavily on animal pollinators, collectively accounting for approximately 35% of global crop production (FAO, 2016). However, intensive farming, ecological degradation, pesticide overuse and invasive species have caused rapid declines in native species, impairing ecological functions. This hidden erosion makes biodiversity loss one of the least predictable and least reversible forms of resilience depletion in agrifood systems.

### 1.2.5 Typical Characteristics of Multiple Shocks and Risks

Shocks confronting the current agrifood system exhibit four distinctive features:

● Escalating risk intensity: Risks have evolved from routine fluctuations into more severe and less predictable disruptions. Recent examples include drought–flood alternation in major grain-producing regions, trade restructuring driven by geopolitical conflicts, and the cross-border spread of emerging diseases. These developments have exceeded the scope of conventional risk-management approaches based mainly on historical experience. Consequently, traditional risk management models based on past practices have become increasingly inadequate.

● Growing risk frequency: Major hazards have shifted from sporadic emergencies to recurrent, overlapping occurrences. The intervals between extreme weather events, geopolitical frictions and public health crises keep shortening. The system often has to cope with new disturbances before fully recovering from prior shocks. The conventional linear cycle of crisis – recovery – stability has been broken, leaving the system in a perpetual state of vulnerability.

● Structural risk interconnection: Risks have transitioned from isolated incidents to synchronous resonance. Climate hazards, geopolitical tensions, epidemics and ecological degradation reinforce one another within the same temporal and spatial context. Ecological degradation weakens agriculture's capacity to buffer climate shocks, while geopolitical conflicts amplify localized production declines into global confidence crises. The overall impact far outweighs the sum of individual risk effects.

● Amplified cascading transmission: Risk propagation has changed from linear attenuation to network cascading effects. Local disruptions spread rapidly via multiple channels including supply chains, price signals and public sentiment, eventually turning failures in a single segment into system-wide crises across the entire industrial chain.

It is evident that the vulnerability of agrifood systems is no longer confined to individual links, but is profoundly shaped by the interplay of multiple risk factors. Accordingly, it is necessary to move beyond the traditional emergency management framework and advance systemic resilience building across the full industrial chain.

## 1.3 What Constitutes a Resilient Agrifood System?

### 1.3.1 Concept and Basic Principles of Resilient Agrifood Systems

(1) Concept Definition: A Resilience Paradigm for Forward Transition

The Chinese term *renxing* (resilience) derives from the character ren. According to Explaining Simple and Analyzing Compound Characters (Shuowen Jiezi), *ren* is defined as "flexible yet firm". It describes the property that a substance may deform under external force or shocks while retaining its overall structural integrity. Rather than rigid resistance, this concept refers to the ability to sustain existence through appropriate deformation, namely, maintaining core operational functions by proactively adjusting internal structures. This semantic connotation lays an important conceptual foundation for understanding agrifood system resilience. Resilience is not merely the ability to restore stability after disturbances, commonly the *bouncing-back resilience*. But The bouncing-back model is widely applied in engineering and certain ecological system analyses, it faces two fundamental limitations when applied to agrifood systems.

First, external shocks are often irreversible. The long-term cumulative impacts of climate change, continuous tightening of resource constraints, and profound restructuring of geopolitical patterns make it impossible for agrifood systems to revert to their pre-shock states. Second, existing agrifood systems inherently contain structural flaws that call for deliberate rectification, such as inefficient resource utilization, limited participation of smallholder farmers, and unequal access to nutritious food.

Against this backdrop, research on agrifood system resilience is gradually shifting from the bouncing-back paradigm toward bouncing-forward resilience, which emphasizes a system's capacity to reorganize actively and evolve into a superior steady state after shocks. In *The State of Food and Agriculture 2021*, the Food and Agriculture Organization of the United Nations (FAO) defines agrifood system resilience as the *capacity of agrifood systems to guarantee long-term sustainable access by all people to adequate, safe and nutritious food at all times, and to sustain the livelihoods of all actors engaged in the system when confronted with any shocks* (FAO, 2021). Centered on the sustained functional integrity of agrifood systems, this definition covers both shock resistance and recovery, and incorporates livelihood security and structural sustainability into resilience assessment. It aligns closely with the bouncing-forward framework and serves as the analytical benchmark for assessing the resilience of China's agrifood systems in this report.

(2) Basic Principles: Five Core Guiding Tenets

Following the logical hierarchy from fundamental underpinnings to overarching goals, the building of a resilient agrifood system shall adhere to the five core principles below:

● Nutrition and Health Principle. As the ultimate goal of a resilient agrifood systems, this principle aims to ensure all populations, regardless of time, location and socioeconomic conditions, to have consistent access to safe, sufficient and nutritionally balanced diets. It drives the transition from merely guaranteeing basic food supply to prioritizing nutrition well-being.

● Risk Adaptation Principle. As the second tier of resilience building, this principle requires the system to be capable of withstanding shocks, adapting to changes and learning lessons from crises. It enables sustained operational performance amid overlapping risks and facilitates structural optimization and industrial upgrading.

● System Integration Principle. Positioned as the third tier, this principle draws on the *cask effect*, holding that the overall resilience of an agrifood systems is determined by its weakest link. A holistic perspective is required to coordinate all segments including production, circulation and consumption, so as to prevent cascading risks from undermining nutrition security.

● Redundancy Safety Principle. Serving as the fourth tier, this principle is guided by the Big Food Concept. It not only safeguards staple food security, but also coordinates the supply of meat, eggs, milk, fruits, vegetables, aquatic products and edible fungi to diversify food sources. Meanwhile, it leverages warehousing and logistics systems to enhance food reserve and turnover capacity, achieving diversified supply and adequate backup stocks.

● Sustainability Principle. As the cornerstone of resilient agrifood systems, this principle warns against policy practices that compromise long-term capacity for short-term gains. It avoids pursuing temporary stability at the cost of excessive resource consumption, fiscal subsidies and ecological degradation, so as to consolidate the ecological foundation for the long-term development of agrifood systems.

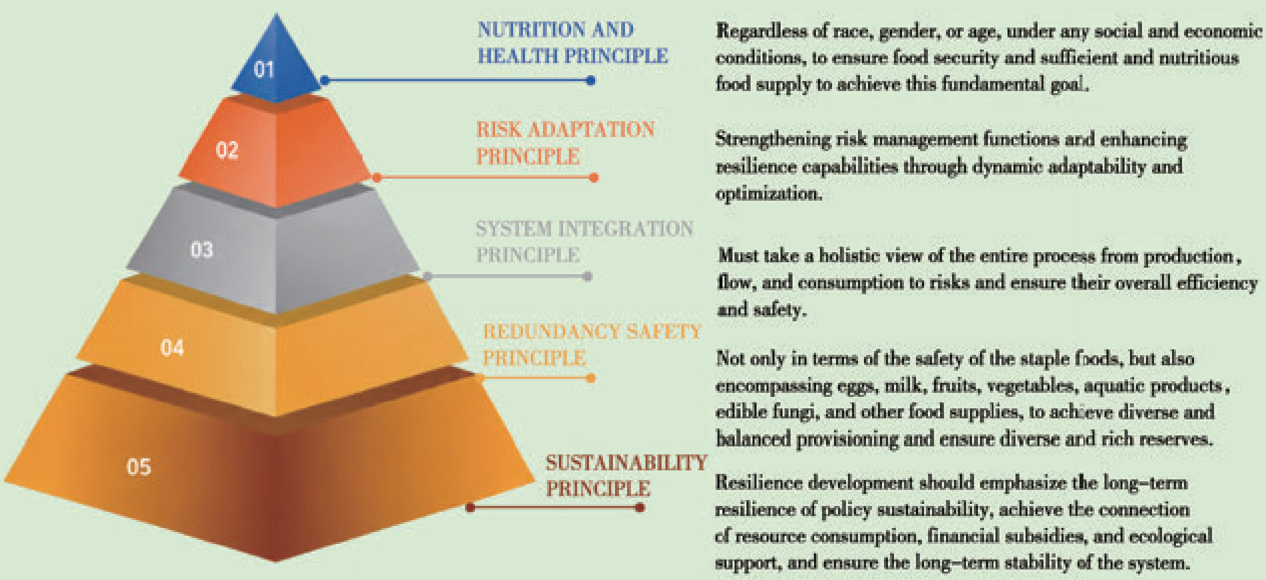
Evidently, the requirements for a resilient agrifood systems go far beyond the single dimension of traditional food security. It attaches importance not only to food quantity, but also to the affordability of healthy diets and accessibility of quality nutrition. It ensures all stakeholders, especially vulnerable groups including smallholder farmers, women and low-income households, can reliably obtain food and nutrition over the long term amid various shocks.

Although resilience has emerged as a systematic analytical framework in recent years, its core ideas have long been embedded in the long-term policy practices of China's agrifood sector. Relevant policy initiatives, from upholding the bottom line of food security and establishing nutrition intervention mechanisms, to fostering diversified food supply systems and comprehensively advancing rural revitalization, embody the multi-dimensional implications of resilience building at different levels (Table 1-1).

### 1.3.2 Dynamic Evolution of Resilient Agrifood Systems: Resistance, Recovery and Transformation

As reflected in the concept and principles of resilient agrifood systems, resilience represents a dynamic evolutionary process underpinned by three interrelated, mutually supportive and synergistic capabilities. As illustrated in Figure 1-3, the agrifood system undergoes three sequential evolutionary phases

**Figure 1-2 Construction Pathways and Core Principles of Resilient Agrifood Systems**

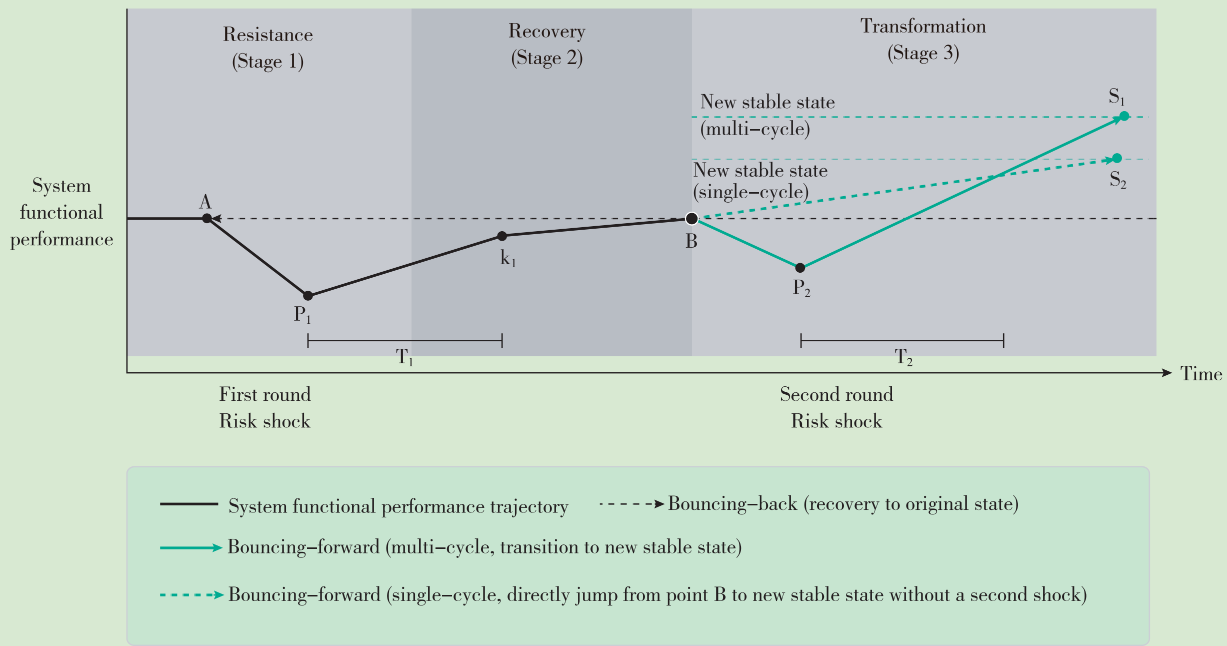



**Source:** Created by the authors.

**Table 1-1 Review of policy documents on capacity building for agrifood systems**

| Issuing Body | Policy Document | Year | Main Content |
|---|---|---|---|
| The 4th Session of the 14th National People's Congress | Outline of the 15th Five-Year Plan for National Economic and Social Development of the People's Republic of China | 2026 | Adhere to the overall planning of development and security, pursue security through development and seek development under security. Strengthen bottom-line thinking, effectively forestall and defuse various risks, enhance economic and social resilience, and safeguard the new development pattern with a new security architecture. |
| The Central Committee of the Communist Party of China, the State Council | Plan for Accelerating the Building of a Strong Agricultural Country (2024–2035) | 2025 | Prioritize the stable and secure supply of grain and important agricultural products, implement the strategies of securing grain production via farmland and technological advances, and consolidate the material foundation for building a strong agricultural country. (1) Improve the production capacity of grain and key agricultural products; (2) Improve supportive policies for grain production; (3) Strengthen reserve and regulation of grain and major agricultural products; (4) Establish a diversified food supply system. |
| The Central Committee of the Communist Party of China, the State Council | Comprehensive Rural Revitalization Plan (2024–2027) | 2025 | Further consolidate the foundation of national food security, steadily boost comprehensive agricultural production capacity, and ensure that Chinese people firmly hold their food bowls in their own hands. |
| Ministry of Agriculture and Rural Affairs, National Health Commission, Ministry of Industry and Information Technology | Outline for China's Food and Nutrition Development (2025-2030) | 2025 | Establish the perspectives of comprehensive agriculture and a broader food system. On the basis of guaranteeing the stable and safe supply of grain and key agricultural products, accelerate the construction of a diversified food supply system, deepen supply-side structural reform, strengthen consumption-driven guidance, rely on innovation to advance nutrition agricultural production, food processing and food consumption, advocate civilized and healthy lifestyles, foster a more balanced and healthy dietary nutrition structure, and meet people's growing demands for nutrition and health. |
| The Central Committee of the Communist Party of China, the State Council | Healthy China 2030 Planning Outline | 2016 | Establish and improve the resident nutrition monitoring system, implement nutrition interventions for key regions and vulnerable groups, focus on addressing micronutrient deficiencies and excessive intake of high-calorie foods such as oil and fat among certain groups, and gradually tackle the coexistence of undernutrition and overnutrition among residents. |

**Figure 1-3 Dynamic Evolution of Resilient Food Systems in Three stages: Resistance, Recovery, and Transformation**




**Source:** Created by the authors.

when confronted with sudden risks. In Phase 1, system functions plummet to the lowest point (P1), where the system's resistance capacity is put to the test. Upon shocks, the system adopts buffering and absorption mechanisms to minimize losses. In Phase 2, system functions gradually rebound to Point k1, requiring solid recovery capacity. During the post-shock period, the system restores its functions in a faster, fairer and more inclusive manner via structural and strategic adjustments. Phase 3 branches into two distinct pathways. Path A refers to *bouncing-back*, whereby the system returns to its initial state (Point B) along the original trajectory. If the original system is inherently fragile, such restoration may lead to accumulated vulnerability. Path B stands for *bouncing-forward*, namely structural transformation guided by the green arrow. The system transcends the original equilibrium and evolves toward a new steady state featuring higher efficiency and greater sustainability. The three phases are elaborated in detail as follows.

(1) Phase 1: Resistance Capacity

Resistance capacity denotes the ability of an agrifood system to maintain core functions and avoid systemic failure amid external shocks. Its core mechanisms lie in structural redundancy and functional diversity: when individual nodes are impaired, alternative routes and supply sources enable the system to maintain basic operations. Effective early warning systems serve as a prerequisite for resistance capacity, allowing proactive responses before shocks strike and confining losses within a manageable boundaries.

China's agrifood system demonstrates strong resistance in securing stable supply of staple grains, as well as continuous provision of diversified foods including vegetables, fruits, livestock products, aquatic products, dairy and edible oil. Currently, China has built robust capacities in production, processing and cross-regional distribution, which can meet the food demand of its large population under normal conditions. Nevertheless, structural vulnerabilities persist within the system. Some fresh agricultural products rely heavily on cold chain logistics and instant delivery; certain feed, oil-bearing crops and dairy raw materials are highly dependent on overseas markets; urban consumption is largely reliant on platform-based distribution and large wholesale markets. Once major producing regions, key logistics hubs, cold chain facilities or global supply chains are disrupted, the stability and accessibility of food supply could be compromised. Therefore, efforts to enhance resistance capacity should cover not only food security, but also the overall stability of diversified food supply, processing and reserve systems, cold chain logistics, retail and nutrition security.

(2) Phase 2: Recovery Capacity

Recovery capacity refers to the capability of an agrifood system to rebalance supply and demand and restore people's access to food after shocks. The recovery process bears distinct social attributes. While recovery efficiency matters, equity is equally essential. A rapid supply restoration exclusively for high-income groups alongside sustained barriers to food and nutrition access for vulnerable populations constitutes incomplete resilience, known as inequitable recovery.

China has established sound mechanisms for food reserves, price regulation and market supply guarantee, which have effectively stabilized market expectations and ensured basic food supply during major emergencies. However, notable disparities in recovery performance exist across regions, product categories and social groups. Eastern urban areas generally resume food supply more rapidly thanks to well-developed logistics, cold chain networks and retail channels, whereas central and western rural areas, remote regions with poor transportation face longer recovery cycle. Recovery speed also varies by food type. Staple grains and storable processed foods can be restored efficiently relying on reserve systems. By contrast, fresh and nutrient-dense foods such as vegetables, fruits, meat, eggs, milk and aquatic products are highly dependent on cold chains, wholesale markets and last-mile delivery. Even when total food supply at the household level bounces back quickly, vulnerable groups including children, pregnant women and the elderly may experience lagged recovery in dietary diversity and micronutrient intake, resulting in latent nutrition gaps.

(3) Phase 3: Transformation Capacity

As the core of the bouncing-forward resilience paradigm, transformation capacity means that after shocks, the agrifood system not only regains original functions, but also proactively restructures its internal mechanisms and evolves toward a more adaptive new steady state. Essentially, it is the system's capacity for learning and self-renewal, which turns every shock into an opportunity to identify structural defects and advance institutional innovation.

Long driven by the development logic of output maximization, China's agrifood system is constrained by multiple structural issues. Heavy reliance on external agricultural inputs limits ecological buffering capacity; smallholder farmers hold weak bargaining power in value chains; and the rising share of ultra-processed foods in residents' diets is closely linked to the growing prevalence of chronic diseases. These problems cannot be resolved merely through incremental adjustments within the existing framework, and call for systemic restructuring of production modes, value chain organization and consumption patterns. By establishing nutrition-oriented policy response mechanisms, implementing targeted guidance on the consumption side, improving circulation efficiency in intermediate links and promoting nutrition-oriented upgrading on the production side, China can steer its agrifood system toward a virtuous cycle characterized by health, resilience and sustainability.

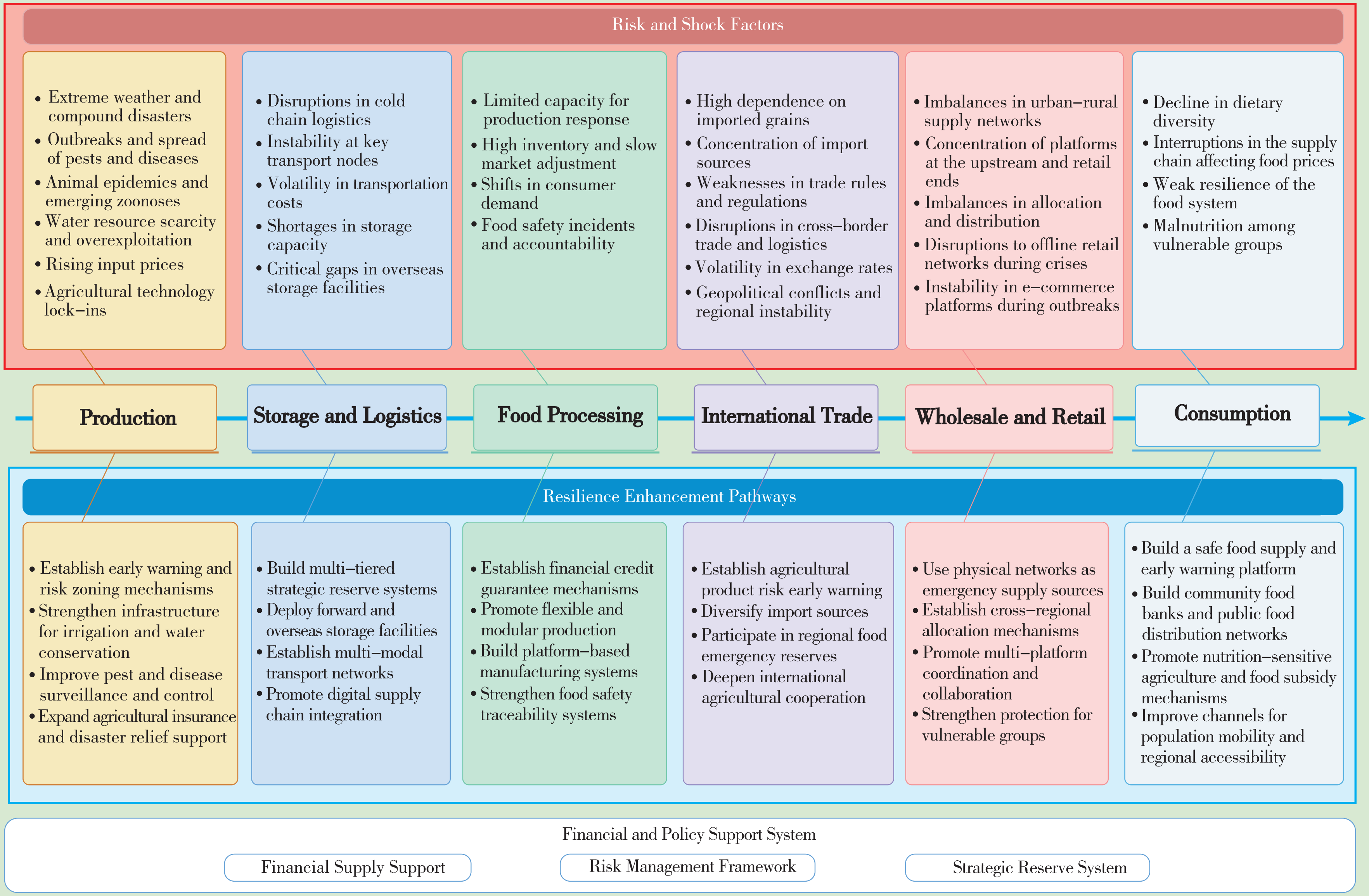
## 1.4 Overall Framework for Building a Resilient Agrifood System

Based on the systematic analysis of risk patterns and theoretical frameworks of agrifood resilience in previous sections, this section proposes a practical overall pathway for fostering resilient agrifood systems, so as to establish a comprehensive action framework for subsequent chapters.

### 1.4.1 Reconsider Resilience Building and Establish an Integrated Multiple Risks Responses Framework

A prerequisite for advancing resilience building is to revisit the fundamental definition of resilience. For a long time, resilience governance in the agricultural and food domain has been inadequately defined and narrowly positioned as a subordinate component of climate risk management. Nevertheless, the frequent overlap of climate shocks, geopolitical turbulence, market fluctuations and public health crises reveals that agrifood systems are confronted with compound challenges featuring concurrent and mutually reinforcing

**Figure 1-4** Framework for Building Resilient Agrifood Systems: Pathways, Solutions, and Policies




**Source:** Created by the authors.

heterogeneous risks. Traditional single-dimensional analytical frameworks are no longer viable. This re-examination leads to two core propositions. First, resilience building shall shift from addressing individual risks to managing multiple risks in an integrated manner. Heterogeneous risks including climate change, market volatility, geopolitical tensions and public health threats should be incorporated into a unified analytical and governance system. It is essential to develop cross-risk dynamic monitoring and scenario simulation mechanisms to enable early prediction of compound shocks. Second, proactive risk prevention and management serve as critical pillars for the structural transformation of agrifood systems. Risk identification must be embedded into the full spectrum of routine governance. Risk management shall evolve from ex-post remedial measures operating outside the system into a core logic running through all agrifood governance practices, driving the transition from an efficiency-oriented development model to a new paradigm that balances efficiency and security.

### 1.4.2 Prioritize Resilience Capacity Improvement to Catalyze the Agrifood Systems' Transition toward a Superior Steady State

The underlying logic of resilience building is not to mechanically restore the system to its original state after shocks, but to leverage pressure from disruptions to advance structural upgrading and move toward a new steady state with higher efficiency and sustainability. To this end, coordinated efforts are required across four dimensions: production, intermediate links, consumption, as well as fiscal and financial support, with resistance, recovery and transformation capacities fully integrated into every sector. On the production side, the governance goal goes beyond merely stabilizing output. Instead, it seeks a fundamental shift from high-input yield stabilization to green and climate-adaptive production modes. The promotion of stress-tolerant crop varieties, adoption of climate-smart agricultural technologies and ecological restoration will upgrade resource utilization while enhancing the production system's capacity to cope with climate hazards. For intermediate links, rather than simply restoring original logistics and trade routes, existing structural flaws exposed by shocks should be addressed to build supply chains with greater flexibility, diversification and digitalization, alongside modern logistics networks capable of rapid restructuring. On the consumption side, shocks should be taken as opportunities to guide a systematic upgrade of residents' dietary structure from quantity-oriented supply to nutrition-oriented consumption. In terms of fiscal and financial support, innovations such as green credit, supply chain finance and blended financing models, together with risk reduction and management tools, will channel policy resources into key areas for systemic transformation and foster endogenous momentum for sustained upgrading of agrifood systems.

### 1.4.3 Target Key Weaknesses and Prioritize Resilience Breakthroughs in Circulation and Trade Links

The overall effectiveness of resilience building hinges on identifying and remedying systemic vulnerabilities in a timely manner. In line with the cask effect, the overall resilience of an agrifood system is determined by its weakest link. At present, China has established a solid foundation for staple grain production. By contrast, intermediate links including warehousing, logistics, food processing and international trade remain major bottlenecks restricting overall system resilience. These nodes are where risks tend to amplify most easily and call for collaborative governance among diverse stakeholders. Therefore, current resilience initiatives shall prioritize improvements in intermediate segments. In warehousing and logistics, deploy mobile and schedulable cold storage facilities, and refine rapid response and allocation mechanisms for multi-level emergency reserves. In food processing, accelerate the development of flexible production lines to enable enterprises to adjust production promptly amid raw material shortages and market changes. In international trade, actively diversify import sources of key commodities such as soybeans and corn, optimize the strategic layout of overseas warehouses and transit hubs, participate in the formulation of global regional trade rules, and promote the establishment of coordinated global regional mechanisms for emergency grain reserves.

Meanwhile, accelerate the development of a full-chain digital traceability and early warning system to monitor global agricultural markets, shipping operations and meteorological conditions in real time, so as to block the transmission of localized disruptions into systemic food crises.

### 1.4.4 Take Nutrition Accessibility as the Ultimate Goal and Build an Inclusive Long-Term Guarantee Mechanism Guided by the Broad Food Concept

The ultimate value of resilience building is to ensure universal access to safe, sufficient and nutritionally balanced food amid all types of shocks. Accordingly, the Broad Food Concept should be translated into institutional arrangements covering all populations. On the supply side, it is critical to foster balanced and diversified supplies of grains, vegetables, livestock products, eggs, dairy, aquatic products, and edible fungi. The national food reserve system should be upgraded from a staple grain-focused single structure to a nutrition-oriented comprehensive reserve system with diversified food categories, matching the demand for holistic nutrition security.

On the demand side, targeted measures should be implemented to improve food accessibility in remote and economically disadvantaged regions, ensuring diversified nutrition food can efficiently reach end consumers. Vulnerable groups including low-income populations, children, the elderly and migrant workers are the first to suffer and the last to recover during crises. Their nutrition security should no longer rely on ad hoc relief. Instead, measures such as developing community food banks, improving nutrition assistance networks and optimizing equitable distribution mechanisms will help achieve a fundamental shift from temporary relief to permanent safety nets. Only when nutrition goals and protection for vulnerable groups are systematically incorporated into the resilience evaluation system, can the inclusive nature of enhanced agrifood resilience be fully reflected. Ultimately, the system will accomplish a value transition from basic security defense to comprehensive, people-centered nutrition resilience.

**References**


Asian Development Bank. Evaluating losses associated with African swine fever in the People's Republic of China and neighboring countries [R]. Manila: Asian Development Bank, 2020. https://www.adb.org/sites/default/files/publication/645541/eawp-027-losses-african-swine-fever-prc-neighboring-countries-zh_0.pdf.

Food and Agriculture Organization of the United Nations. Pollinators, pollination and food production: A global assessment [R]. Rome: Food and Agriculture Organization of the United Nations, 2016. DOI: 10.13140/RG.2.1.3021.0088.

Food and Agriculture Organization of the United Nations. The State of Food and Agriculture 2021: Making agrifood systems more resilient to shocks and stresses [R]. Rome: Food and Agriculture Organization of the United Nations, 2021. DOI: 10.4060/cb4476en.

Food and Agriculture Organization of the United Nations. The State of Food and Agriculture 2023: Rethinking agrifood systems resilience [R]. Rome: Food and Agriculture Organization of the United Nations, 2023. DOI: 10.4060/cc5026en.

Glauber J, Laborde D, Mandrioli R. Food and fertilizer export restrictions: A 2022 update [R]. Washington, DC: International Food Policy Research Institute, 2022. DOI: 10.2499/p15738coll2.135673.

The Royal Society. Nourishing ten billion sustainably: Climate change science and solutions, briefing 10 [R]. London: The Royal Society, 2021. https://royalsociety.org/-/media/policy/projects/climate-change-science-solutions/climate-science-solutions-food.pdf.

World Economic Forum. Global risks report 2026 [R]. 21st ed. Geneva: World Economic Forum, 2026. https://www.weforum.org/publications/global-risks-report-2026/.

World Organisation for Animal Health. The state of the world's animal health 2025 [R]. Paris: World Organisation for Animal Health, 2025. DOI: 10.20506/woah.3586.

Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations Children's Fund, et al. The State of Food Security and Nutrition in the World 2025: Addressing high food price inflation for food security and nutrition [R]. Rome: Food and Agriculture Organization of the United Nations, 2025. https://openknowledge.fao.org/bitstreams/c0d70422-ec82-42f5-b2b4-d31eba75384c/download.

Office of the National Commission for Disaster Prevention, Reduction and Relief, Ministry of Emergency Management of the People's Republic of China. National natural disaster situation in China 2025 [R]. Beijing: Ministry of Emergency Management of the People's Republic of China, 2026. (in Chinese)

National Climate Center. Blue book on climate change in China 2024 [M]. Beijing: China Meteorological Administration, 2024. (in Chinese)

Department of Rural Surveys, National Bureau of Statistics of China. Stable summer grain harvest in China in 2025: Interpretation of summer grain production by Wei Fenghua, Deputy Director-General of the Department of Rural Surveys [EB/OL]. (2025-07-10) [2026-05-27]. https://www.stats.gov.cn/sj/zxfbhjd/202507/t20250710_1960378.html. (in Chinese)

Food and Agriculture Organization of the United Nations. The state of the world's land and water resources for food and agriculture: Systems at breaking point—summary report 2021 [R]. Rome: Food and Agriculture Organization of the United Nations, 2021. DOI: 10.4060/cb7654zh.

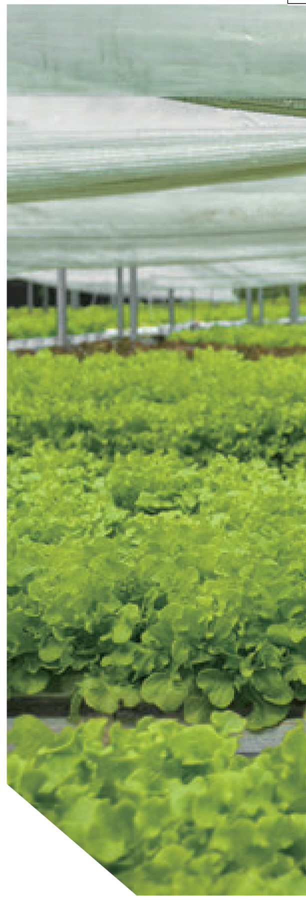
Ministry of Ecology and Environment of the People's Republic of China. China ecological and environmental status bulletin 2024 [R]. Beijing: Ministry of Ecology and Environment of the People's Republic of China, 2025. https://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/202506/P020250604527010717462.pdf. (in Chinese)

Xinhua News Agency. Race against continuous rainfall to safeguard autumn grain harvest across multiple regions [EB/OL]. (2025-10-12) [2026-05-27]. http://www.news.cn/politics/20251012/f0c172707494494987ea3af7cf49427e/c.html. (in Chinese)

Xinhua News Agency. Reporter's notes: The U.S. egg shortage [EB/OL]. (2025-02-14) [2026-05-27]. https://www.xinhuanet.com/world/20250214/ae9c40d5f1bd45eba1b4c00c9df5f61b/c.html. (in Chinese)

Institute of Applied Ecology, Chinese Academy of Sciences. Soil pollution control should follow China's own restoration path [EB/OL]. (2019-08-27) [2026-05-27]. https://www.iae.cas.cn/gb2019/kxcb/kpwz_156500/201908/t20190827_5370746.html. (in Chinese)

# Chapter 2



# Enhancing Resilience of Food Production: Multiple Shocks and Adaptive Response Measures

ZHANG Yumei[1], ZHAO Luyang[1], XIA Fang[1], LAN Xiangmin[1], WANG Ziwen[1], JIN Futong[1], LIU Wenfeng[2], and FAN Shenggen[1]

1. Academy of Global Food Economics and Policy, China Agricultural University
2. College of Water Resources and Intelligent Engineering, China Agricultural University

## Key Findings

● China's food production has remained overall stable, marked by steady production growth but with growing structural divergence. At the national level, the supply of staple foods is secure, grain production capacity robust, and overall nutrients provision sufficient. Provincial food production, however, is far more volatile. Cash crops, certain livestock products, and supplies of protein and fat are all prone to cyclical fluctuations, while cash crops and livestock commodities also see considerable price swings, pork most of all in this regard.

● Climate change, pests and diseases hit crop production hard, with effects that ripple out to livestock and the agrifood systems as a whole. Epidemic diseases weigh heavily on livestock production and animal protein availability, whereas higher import costs for intermediate inputs matter far less. Any single risk tends to have a modest overall impact, but when several converge, more food categories suffer production losses, price hikes, and rising imports. Such pressures trickle down through food processing and catering sectors, and ultimately the macroeconomy.

● Existing measures can cushion these shocks effectively, but they cannot fully offset compound risks over long run. Infrastructure and improved breeding help stabilize grain production, pest and disease control safeguards steady supplies of vegetables and fruits, and vaccination and biosecurity protocols keep livestock and aquatic production on an even keel. Yet under a materialized compound shock, even a full package of measures leaves food production, prices, imports, and related industries significantly affected.

## Policy Recommendations

● Build a multidimensional resilience-monitoring system categorized by region, product, and risk type, and strengthen the capacity for reformed governance. Given the pattern of steady total amount yet structural divergence, monitoring should zero in on key provinces and major production zones, forming a dynamic system that tracks the interplay of region, product, and risk. The priority is to follow changes in major agricultural products and inputs closely, sharpen early warning for extreme weather events, biological epidemics, and market anomalies, and keep localized risks from snowballing into systemic crises.

● Tailor measures to each category to close resilience gaps in priority areas and make food production more stable. With grain capacity secured, resilience-building should target the areas that swing the most. This means strengthening farmland water conservancy and breeding stress-resistant varieties for grain cultivation; for vegetables and fruits, scaling up green pest and disease control and improving cold chain logistics; and for livestock and aquaculture, raising the level of animal disease surveillance, vaccine development, and biosecurity, so as to underpin a steady, diversified supply of food, particularly protein.

● Align short-term emergency response with long-term capacity building to move toward whole-process risk management. The short-term emergency system spanning pre-disaster early warning, in-disaster emergency response, and post-disaster recovery should be refined, with quicker turnaround on replanting and crop substitution, the dispatch of agricultural inputs, mechanical field work, disease prevention and control, and insurance payouts. At the same time, short-term fixes must not come at the expense of the industry's long-term development. Long-term adaptive capacity needs sustained investment in agricultural infrastructure, technological innovation, biosecurity, and digital monitoring, steering resilience governance toward a whole-process risk management paradigm.

## 2.1 Introduction

As climate change intensifies, geopolitical conflicts flare more often, and international markets for agricultural products grow more volatile, a web of risks, including extreme weather, biosecurity threats, and surging energy and farm inputs prices, poses an ongoing challenge to global food security and the stability of food supply chains. For China, a country with a vast population and high food consumption, securing a steady supply of grain and other key agricultural products is all the more pressing amid tightening resource and environmental constraints, structural shifts in the agricultural workforce, and the dietary upgrading of domestic consumers. China's overall food production capacity has climbed steadily in recent years, yet supply-demand mismatches for certain products, mounting pressure on arable land and water, and the compounding of natural and market risks have all added to the uncertainty surrounding production.

Existing research has paid limited attention to the production resilience of agrifood systems under multiple shocks. To address this gap, the chapter offers a systematic assessment of the resilience of China's food production across the dimensions of production nutrient supply, and prices. It examines the main risk factors, like climate change, pests and animal diseases, resource and environmental constraints, and rising input costs. The study further reviews current supportive policies, and quantifies how different shocks and policy responses bear on resilience. On this basis, this chapter puts forward targeted recommendations for strengthening resilience and securing a stable supply of grain and other vital agricultural products.

## 2.2 The State of Resilience in China's Food Production

Resilience in food production is about more than output stability; it also shapes whether nutrients supply holds up over time and whether market prices stay relatively stable. This study therefore assesses food production resilience along three dimensions, including  output, food nutrient supply, and prices, using fluctuation magnitude as its core measure. The smaller the fluctuation, the better food production withstands external shocks and the superior its resilience; larger fluctuations point to weaker resilience. Unless noted otherwise, the term "fluctuation" below refers to the year-on-year rate of change in these indicators over a given period.

### 2.2.1 Production Fluctuations

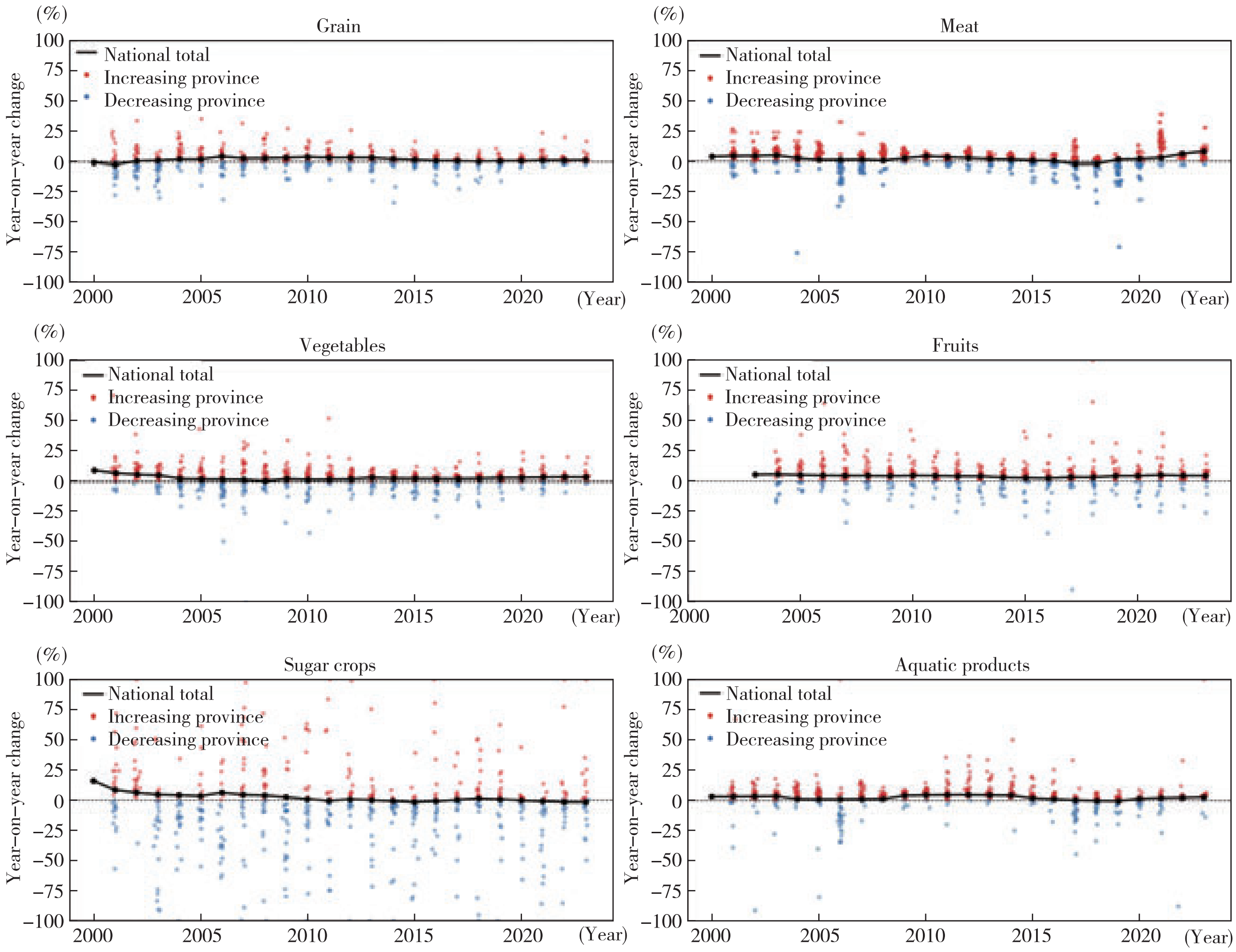
Looking at production fluctuations, the resilience of China's food production shows two defining features: relatively steady nationally but markedly volatile at the provincial level, and relatively stable for grain but considerably more variable for non-grain products.

An analysis of national and provincial output data for major agricultural products from 2000 to 2023 (Figure 2-1) reveals that year-on-year changes in national output are comparatively modest (1%–4%), far below than the provincial range (7%–35%). By product, resilience follows a clear gradient: grain > cash crops > livestock and aquatic products. Grain is the ballast of stable supply, with the lowest fluctuations at both the national and provincial levels (1.54% and 7.25%, respectively). Non-grain products, by contrast, are generally more vulnerable: among cash crops, provincial year-on-year fluctuations reach 20.2% for oilseeds and 28.25% for fruits. Aquatic products swing the most at the provincial level (34.52%), though their national fluctuation is small (1.64%). Livestock products, subject to biological cycles and disease risk, show pronounced cyclical swings: pork's provincial year-on-year fluctuation is 14.7% (against a national average of 3.56%). These differences reflect not only the length of production cycles and exposure to natural and biological risks, but also the degree of marketization and the strength of targeted policy support.

### 2.2.2 Fluctuations in Food Nutrient Supply

Drawing on the output of major agricultural products and their nutrient content per unit, this study converts all foods on a common basis, to the supply of dietary, carbohydrates, protein, and fat, for standardized comparative analysis. The results (Figure 2-2) demonstrates that from 2000 to 2023, China's supply of major nutrients held broadly steady, with no sustained decline, though the pattern of cyclical fluctuation varied considerably. Between 2001 and 2019, fluctuations were relatively mild: the year-on-year variation rates of energy, protein, fat, and carbohydrates swung by 2.68%, 2.92%,

Figure 2-1 **Output fluctuations of major agrifood products at the national and provincial levels in China, 2000–2023**




**Source:** National Bureau of Statistics of China; authors' calculations.

Figure 2-2 **Fluctuations in Nutrients Supply of Major agrifood Products in China, 2000–2023**


**Source:** National Bureau of Statistics of China; authors' calculations.

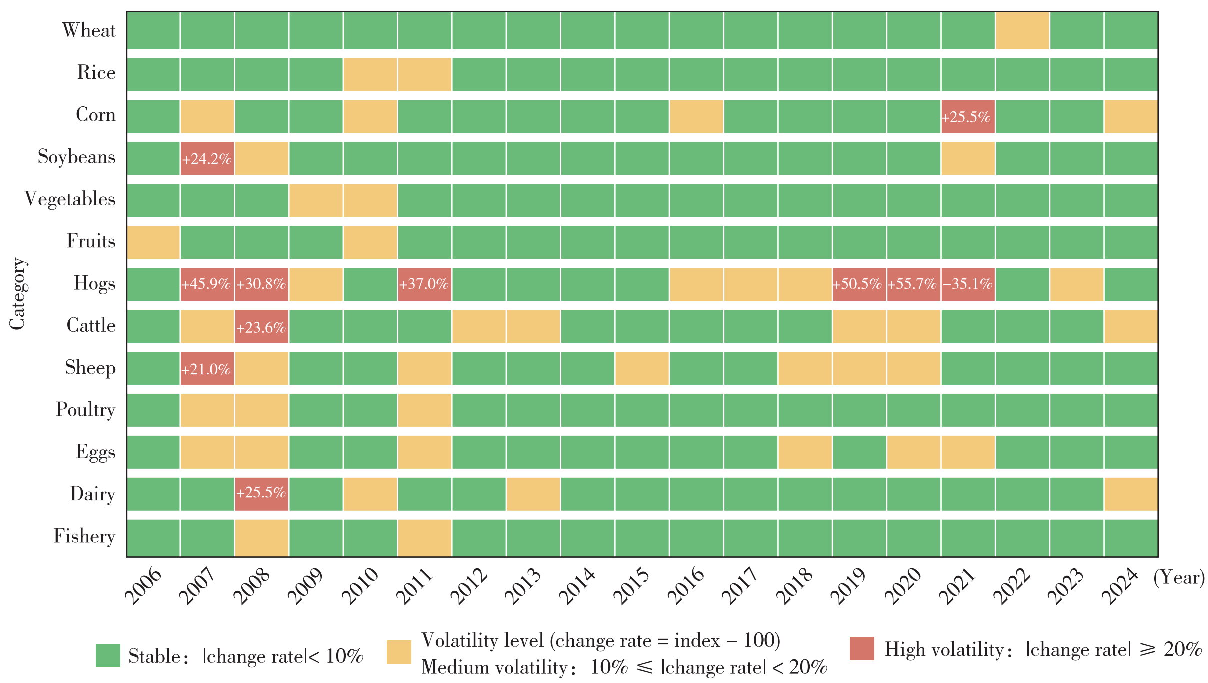
3.59%, and 2.84%, respectively. Since 2020, however, the swings have widened markedly, with protein and fat standing out in particular, their year-on-year fluctuations climbed to 11.31% and 9.21% over 2020–2023, well above earlier levels. This stems mainly from greater volatility in livestock and poultry products, which feeds through to protein and fat supply and has become a structural weak point that resilience in food nutrients supply must address. Carbohydrate supply, by contrast, has stayed relatively stable and resilient, reflecting the role of grain and other staple products as a stabilizer in nutrient supply.

### 2.2.3 Price Fluctuations

The relative stability of prices is a key dimension of food-production resilience. The magnitude of price volatility and its knock-on effects bear directly on whether producers can plan with confidence, the long-run robustness of the system, and consumers' food expenditure burdens and food accessibility.

Drawing on China's producer price index of agricultural products from 2006 to 2024, this study uses quantile regression to identify abnormal price shocks (Figure 2-3). The results indicate that China's agricultural price system has, on the whole, avoided prolonged, violent upheaval; the production end has some capacity to adjust prices and absorb pressure. Nevertheless, the degree of fluctuation differs markedly across categories, with sharp anomalies in certain years and a strong structural character. By category, staple grains have held their prices relatively steady and proved highly resilient, thanks largely to policies such as minimum purchase prices and reserve adjustments that effectively smooth out swings, together with a steady and sustained supply. Corn is the exception: its price has both risen and fallen sharply, driven by the combined pull of feed demand, inventory adjustments, and policy iterations. Cash crops are more exposed to weather, seasonal supply, transport and distribution, and spillovers from global markets, so they swing more widely than staple grains. Vegetables and fruits fluctuate noticeably, mostly within a ±10% band, and soybeans too have seen sizable swings in some years. Price volatility is most pronounced for livestock products, with pork swinging the most and for the longest: its year-on-year increases reached 45.9% in 2007 and 55.7% in 2020, followed by a steep 35.1% drop in 2021. This result stems from overlapping pressures on the hog industry, from epidemic outbreaks to capacity readjustments and shifting market expectations.

**Figure 2-3 Fluctuations in the Producer Price Index of Major Agrifood Products in China, 2006–2024**




**Data Source:** Price data are from the National Bureau of Statistics of China; calculations by the authors.

## 2.3 Multiple Risks Facing China's Food Production and Corresponding Policies

The risks confronting the food production system are taking on a new character, that is more persistent, more compounded, and more prone to cascading transmission. To address this, the study goes on to pin down core risk drivers that bear on system resilience and to map the policy intervention tools, thereby providing the theoretical grounding and data support for the scenario simulations and policy-effectiveness assessments that follow.

### 2.3.1 The Multiple Risks Facing China's Food Production

(1) Mounting climate change risk

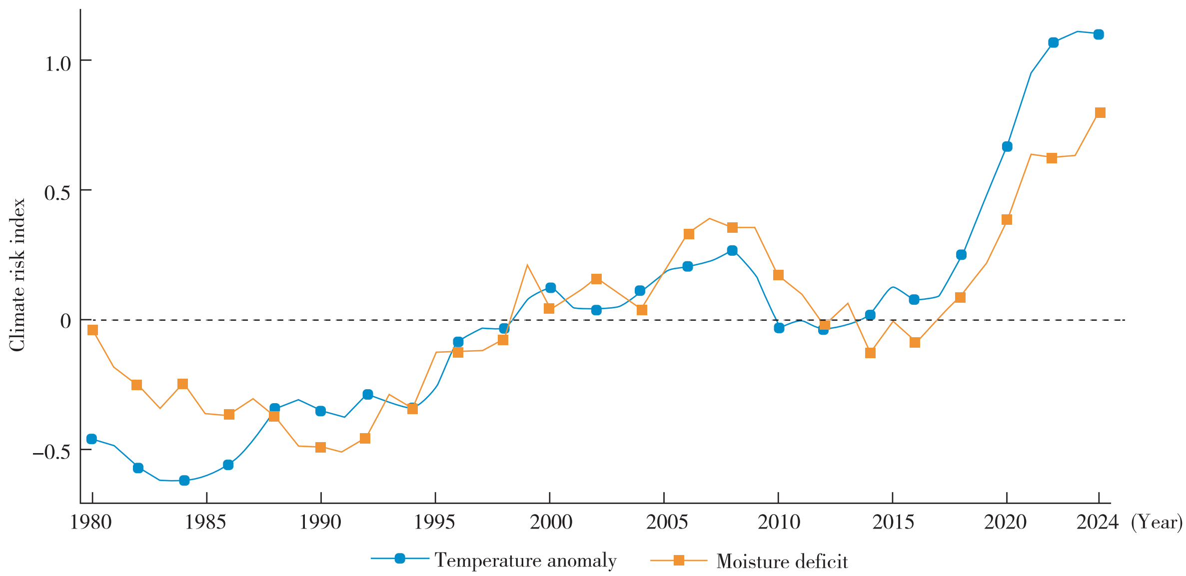
Under climate change, the weather-related hazards to food production are shifting from isolated disaster shocks toward compound risks that combine multiple types and affect multiple stages of production. As Figure 2-4 shows, from 1980 to 2024 the national temperature anomaly trended significantly upward, with warming becoming all the more marked after 2010. At the same time, drought hazards have intensified and have run high in recent years overall, signaling that the climatic environment in which food is produced is undergoing long-term shift.

Climate disasters remain a major source of risk to stable food production. Although the area of crops affected and severely damaged nationwide trended downward over 2010–2024, this does not mean their impact has eased; rather, it reflects the episodic, fluctuating nature of agricultural disasters. The data show that in 2013, 2016, and 2020 the area of crops affected nationwide reached 31.35, 26.22, and 19.96 million hectares, respectively, with the severely damaged area reaching 14.30, 13.67, and 7.99 million hectares. This points to climate shocks erupting in concentrated bursts in particular years, hitting some major and vulnerable production zones hard, along with crops at critical growth stages. Once extreme weather events, including heatwaves, drought, heavy rainfall, floods, or typhoons, coincide with key junctures such as sowing, jointing, heading, grain-filling, or harvesting, even a nationally manageable affected area can still trigger violent local output swings. Such falling regional supply, inter-regional grain allocation pressures, and shifting market expectations collectively pose a tangible threat to nationwide stability in food production.

(2) Persistently high incidence of crop pests and diseases

In recent years, the total area affected by crop pests and diseases nationwide has remained persistently high. Between 2021 and 2025, although the affected area fluctuated, it stayed substantial, reaching 2.52 billion mu (cumulative occurrence area) in 2025 (see Table 2-1),

**Figure 2-4 Trends in temperature anomalies and drought risk in China, 1980–2024**




**Source:** ERA5 reanalysis data.

**Note:** The indices are standardized relative change levels, used to compare the long-term trends of different climate risks.

**Table 2-1 Occurrence of pests and diseases for staple crops in China, 2021–2026 (Unit: 100 million mu/time)**

| Year | Total National Occurrence Area | Major Wheat Pests and Diseases | The "Three Pests and Two Diseases" of Rice | Major Maize Pests and Diseases | Occurrence Characteristics |
|---|---|---|---|---|---|
| 2021 | 21 | 4.7 | 11.2 | 4.4 | Severe outbreak trend; expected to pose risks to over 70% of production areas |
| 2022 | 20.26 | 4.5 | 10.3 | 4.8 | Generally stable; the occurrence area of pests and diseases for each crop remained at normal levels |
| 2023 | 20.2 | 4.7 | 10.1 | 5 | Overall slight increase, with high risk of localized outbreaks |
| 2024 | 23.3 | 5.6 | 10.7 | 5.57 | Significant increase; both the total national occurrence area and the occurrence areas of pests and diseases for each crop rose sharply |
| 2025 | 25.18 | 6.06 | 11.2 | 6.67 | Reached a peak; both the total national occurrence area and the occurrence areas of pests and diseases for each crop hit new highs for the period |
| 2026 | 22.5 | 5.06 | 10.1 | 6.15 | Slight decline; the occurrence area of maize pests and diseases remained high (high single-point risk) |

**Source:** National Agro-Tech Extension and Service Center, Forecast of Occurrence Trends of Major Crop Pests and Diseases in China, various years.

**Note:** The "three pests and two diseases" of rice refer to the three major pests and two major diseases: striped stem borer, brown planthopper, rice leaf folder, rice blast, and rice sheath blight.

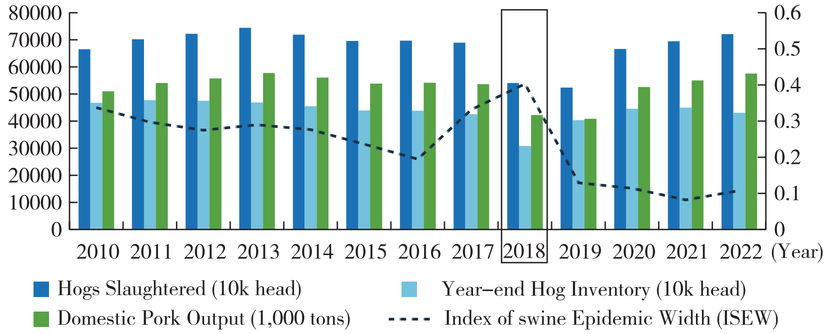
making it one of the major risks to stable yields. The areas hit by major pests and diseases in the three staple grains, wheat, rice, and corn, have fluctuated in tandem, showing that outbreaks are not isolated incidents but carry a clearly systemic spillover character.

Looking ahead, the dynamics pests and diseases occur may change in three significant respects. First, rising average temperatures and milder winters will alter overwintering conditions, bringing outbreaks earlier and prolonging the period of damage. Second, as agricultural trade, the movement of seedlings, and logistics networks develop further, transmission pathways will grow more complex. A typical example is the fall armyworm invaded in 2019 and spread across 25 provinces within a year. Third, with a warming climate, tropical and subtropical fruit and vegetable production zones, characterized by fast pests and diseases reproduction and overlapping generations, may face sustained high-intensity control pressure for long term. Meanwhile, the traditional reliance on a single approach centered on chemical control has begun to show its limits, from growing resistance to diminishing marginal returns. The challenge ahead will shift from preventing pest outbreaks entirely to maintaining stable output amid sustained high pressure and sudden shocks.

(3) Rising biosecurity risk in livestock farming

The speed and reach of animal disease transmission are growing increasingly unpredictable, and this has

**Figure 2-5** ISEW and changes in hog production in China, 2010-2022




**Data source:** China Statistical Yearbook and BRIC Agricultural Database.

become the chief biosecurity challenge restricting China's livestock sector. In recent years, severe infectious diseases such as African swine fever (ASF) and avian influenza have left a deep mark on the industry. The 2018 ASF outbreak serves as a typical case (Figure 2-5): that year the hog inventory and the number of hogs slaughtered plunged by 27.5% and 21.5%, respectively, setting off violent swings in pork prices. Although China has made notable strides in disease prevention and control, accelerating global climate change and the ongoing evolution of farming models are speeding up viral mutation and diversifying transmission pathways, suggesting high-pathogenic infectious diseases may strike the livestock sector with greater frequency. On top of this, epizootic such as foot-and-mouth disease and brucellosis pose a direct threat to production safety in sub-sectors like dairy farming.

(4) Tightening land and water resource constraints

China's food production faces long-standing rigid constraints, seen in an increasingly tight freshwater supply and a weak foundation of cultivated-land quality. Unlike short-term shocks such as disasters and diseases, resource constraints rarely cause a sharp drop in output within a single year. Instead, they gradually erode the agrifood systems' capacity to withstand shocks and recover, by squeezing the room for agricultural inputs, reducing production flexibility, and pushing up the cost of keeping output stable.

From 2004 to 2024, agricultural water use per unit of effective irrigated area trended downward overall (Figure 2-6). This reflects steady gains in irrigation efficiency, but it also points indirectly to food production's deepening reliance on water-saving irrigation, upgraded irrigation infrastructure, and better water allocation, set against tightening water constraints and intensifying competition for water across sectors. Looking ahead, amid the uneven distribution of rainfall in space and time, a rising risk of abrupt swings between droughts and floods, and sharpening competition for water among agriculture, residential consumption, and industry, securing a stable food supply will continue to face considerable pressure from water constraints.

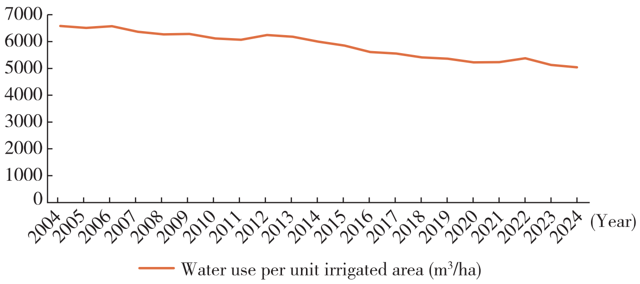
A comparison of cultivated land by quality grade nationwide (Figure 2-7) shows that in 2014, the medium- and low-grade arable land totaled 1.33 billion mu, or 72.7% of the national stock, of which low-grade land accounted for 510 million mu, or 27.9%. By 2024 the share of medium- and low-grade land had edged down to 68.8%, though the absolute area still stood at 1.39 billion mu, with low-grade land at 444 million mu, or 21.9%.[1] Clearly, even as the structural composition of cultivated land has improved somewhat, the proportion of medium- and low-grade land remains high, an indication that a sizable portion of food production still relies on land with limited fertility.

(5) Rigidly rising pressure on input and labor costs

Rigidly rising costs are another prominent challenge for China's food production. Volatile input prices and rising labor costs reinforce one another, steadily eroding the comparative profit margins to food production and weakening producers' expectations in stable returns.

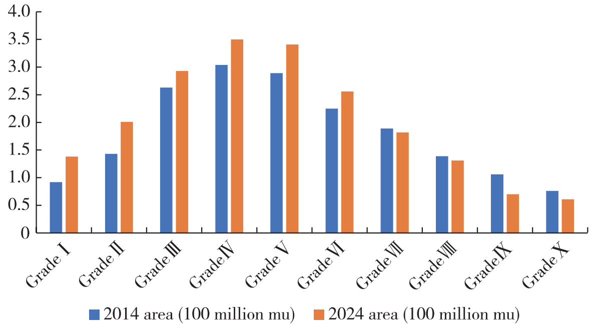
[1] According to the Cultivated Land Quality Grades (GB/T 33469–2016) and the cultivated-land quality grade survey and evaluation framework of the Ministry of Agriculture and Rural Affairs, arable land quality is classified into then grades from Grade 1 (highest fertility) to Grade 10 (lowest fertility). Grades one to three are generally defined as high-quality land, grades four to six medium-quality land, and grades seven to ten low-quality land.

**Figure 2-6 Agricultural water consumption per unit of effective irrigated area in China, 2004–2024 (Unit: $m^3$/ha)**



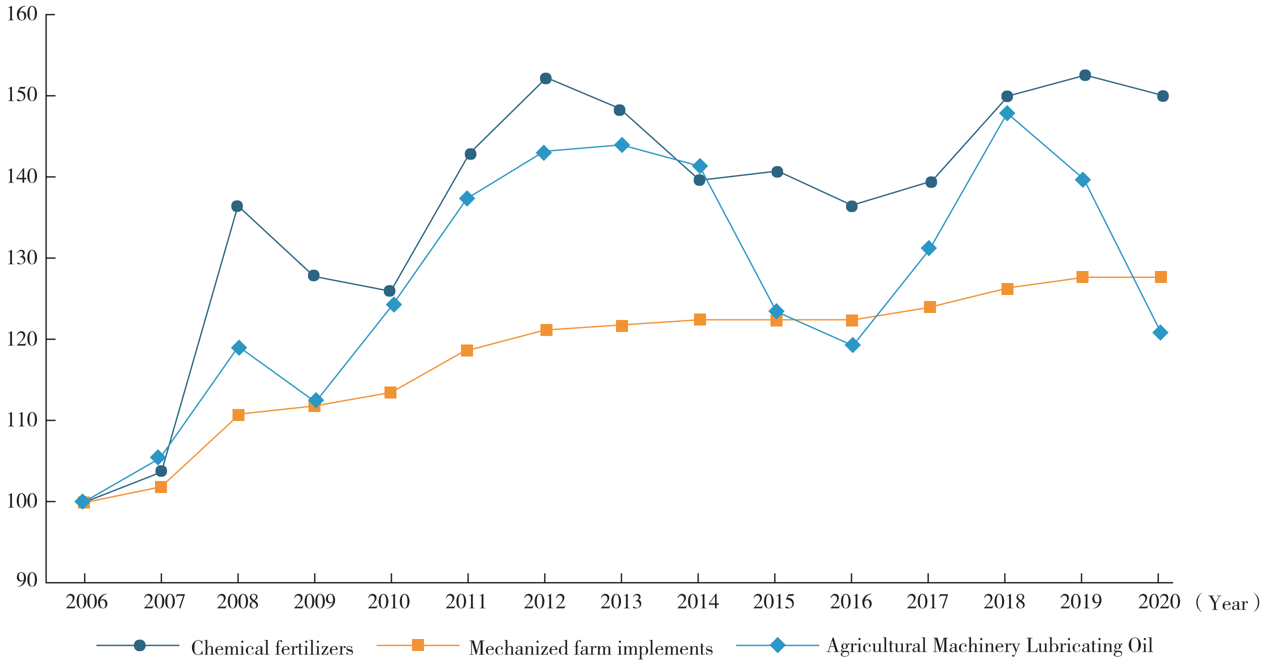

**Data source:** National Bureau of Statistics of China; compiled and calculated by the authors.

**Figure 2-7 Area Comparison of cultivated land quality grade in China, 2014 vs. 2024**




**Data source:** Ministry of Ecology and Environment of the People's Republic of China.

**Figure 2-8 Price index of agricultural inputs in China, 2006–2020 (2006 = 100)**




**Data source:** National Bureau of Statistics of China.

This in turn affects decisions on sowing, restocking, and long-term investment. As Figure 2-8 shows, from 2006 to 2020, the prices of major agricultural inputs in China trended upward overall, with chemical fertilizer rising the most with a cumulative increase of about 49.9%, while pesticides and application equipment, mechanized farm tools, and farm engine oil rose by 31.1%, 27.5%, and 20.8%, respectively, indicating a broad-based increase in input costs. In terms of fluctuation, fertilizer and diesel prices swung sharply, whereas agricultural machinery and pesticides climbed more gently.

At the same time, as rural labor has continued to move into non-agricultural sectors, labor costs in food production have come under sustained upward pressure, though the effect is concentrated mainly in labor-intensive areas. From 2006 to 2020, the average per-mu labor cost for the three staple grains rose from CNY151.90 to CNY412.76, a cumulative increase of

171.7%. Vegetables, fruits, livestock and poultry farming, and some high-value cash crops rely more heavily on labor: labor costs for vegetables, apples, and hogs rose by 287.3%, 409.6%, and 210.3%, respectively. In areas with poor agricultural conditions, fragmented plots, or small-scale family farming, rising labor costs suppress planting willingness and may even lead to farmland abandonment. Moreover, given the high degree of openness to global markets, swings in international energy, fertilizer, and feed prices may transmit to China through input markets, generating cost uncertainty for producers.

### 2.3.2 Policy Measures for Strengthening Resilience in China's Food Production

To address the multiple risks facing food production, China has gradually built an integrated policy framework for food production resilience, spanning disaster emergency response, risk monitoring and early warning, agricultural insurance, input guarantee, infrastructure development, pest and disease control, animal disease prevention, scientific and technological innovation, and resource and environmental management. This framework rests on three dimensions: shock absorption, which lessens the severity of shocks through risk identification and buffering arrangements; rapid recovery, which mitigates losses through post-disaster relief and production-restoration mechanisms; and structural transformation, which steadily enhances the systems' long-term adaptive capacity through infrastructure development and technological progress.

(1) Shock absorption

In recent years, China has steadily improved its meteorological disaster monitoring and early-warning system, building up cross-departmental coordination working mechanisms for weather warnings, farm-condition tracking, and disaster reporting across the diverse agro-meteorological disasters. On pest and disease control, drawing on the national agricultural extension system and the monitoring network for major pests and diseases, authorities issue warnings for major pests and diseases in key crops such as wheat, rice, and corn, and lowers the risk of outbreaks through eco-friendly control and synchronized, unified prevention and treatment. On animal disease prevention, the state has pressed ahead with compulsory immunization, outbreak monitoring, quarantine oversight, and vaccine development and use, easing the impact of major diseases such as African swine fever, avian influenza, and foot-and-mouth disease on the livestock sector. Meanwhile, institutional arrangements such as agricultural insurance, grain reserves, and minimum purchase prices have played a positive role in cushioning price swings, stabilizing production expectations, and protecting farmers' returns.

Yet shock-absorption capacity still falls short. First, risk monitoring remains largely organized around single disasters and managed in silos across separate departments; meteorology, plant protection, disease prevention, water resources, soil quality, and market information are not yet well integrated, making it hard to identify in time the compound transmission risks of different shocks. Second, agricultural insurance and risk-buffering tools still fall short in coverage, depth of protection, and targeting precision, leaving smallholders, remote areas, and low-income operators with relatively weak buffering capacity.

(2) Rapid recovery

Existing policy focuses mainly on stabilizing normal production, reducing direct economic losses, and restoring supply capacity as quickly as possible after a disaster or crisis. Over recent years, China has established a fairly systematic emergency response mechanism for agricultural disasters, covering disaster coordination, emergency consultation, the disbursement of relief funds, cross-regional allocation of agricultural inputs, post-disaster technical guidance, targeted insurance claims settlement, and production recovery in affected areas. After natural disasters, they help affected areas resume production by guiding field management, promoting replanting and switching of crops, and coordinating the supply of inputs such as seeds, fertilizer, and pesticides. In response to livestock disease shocks, they stabilize farmers' sentiment through outbreak handling, culling compensation, harmless disposal, restocking and re-farming, capacity monitoring, and market regulation. Beyond this, grain reserve adjustments, unimpeded agricultural logistics mechanisms, and arrangements to secure the market supply of agricultural products have also played an important role in mitigating market turbulence and anchor market expectations.

However, current rapid recovery policy faces twofold challenges. On efficiency, the policy tools, like agricultural insurance, disaster relief funds, credit support, price regulation, input supply, and the rehabilitation of production and marketing, are spread across different departments and stages, and have not yet fully formed a closed loop running from loss assessment through compensation, production resumption to market recovery. On equity, in the western regions, mountainous and remote areas, and locations with weak infrastructure, suffer from inadequate irrigation, mechanization, warehousing, rural road and input delivery systems, which prolong post-disaster recovery cycles. Furthermore, policy support for smallholders, small and medium-sized farms, and low-income producers is also fairly limited, which makes short-term shocks more likely to turn into medium- and long-term capacity losses.

(3) Structural transformation

Existing policy attempts to strengthen the food production system's adaptability to long-term climate change, resource constraints, and biosecurity risks. In recent years, the state has prioritized high-standard farmland construction, the upgrading of irrigation and water-conservancy facilities, water-saving irrigation, and the protection and improvement of cultivated-land quality, all to bolster agriculture's ability to resist drought, drain floodwater, and keep output stable. On the technology front, policy has consistently emphasized revitalizing the seed industry, breeding stress-tolerant varieties, agricultural mechanization, smart agriculture, and grassroots agricultural extension. On biosecurity, efforts continue on green control of major pests and diseases, coordinated and unified epidemic prevention and treatment, livestock vaccine development, fertilizer and pesticide reduction with higher input efficiency, and recycling agricultural waste into resources.

Medium-and long-term structural transformation policies still have several weak points. First, western and remote regions, as well as areas dominated by medium- and low-yield fields, lag significantly behind in irrigation and drainage, mechanized operations, field road construction, and soil quality improvement. Second, innovations such as stress-resistant varieties, smart-agriculture equipment, pest and disease control technologies, and disease monitoring techniques are still facing barriers to large scale adoption among small and medium-sized operators and in low-income areas, attributable to high upfront cost, inadequate grassroots technical services, and lower farmer organizational levels. Third, policy tends to focus on building single capabilities, paying too little attention to the synergy among infrastructure, pest and disease control, animal disease management, resource conservation, input-cost control, and market stabilization.

The policy priority for future structural transformation lies in driving these measures to land precisely in key regions, staple product categories, and vulnerable links. Relying on socialized agricultural services, digital agriculture, inclusive agricultural finance, and improved subsidy mechanism, policy guidance will shift food production away from a sole focus on raising output toward a resilient development model defined by resource conservation, ecological sustainability, varietal diversification, and long-term adaptation.

## 2.4 Simulation Analysis of Strategies to Boost China's Food Production Resilience

Building on the foregoing analysis of production-side risks in the agrifood systems and China's existing policy responses, this section focuses on simulating the transmission effects of multiple overlapping shocks, including extreme climate disasters, outbreaks of pests, diseases, and animal epidemics, and rising input prices. It further empirically examines the mitigating and adaptive effects of targeted strategies, namely high-standard farmland construction, the breeding of drought- and flood-resistant improved varieties, the development of pest and disease control systems, and disease vaccine R&D.

### 2.4.1 Methodology and Data Sources

This study uses an interdisciplinary modeling approach, coupling the China Agricultural University Agrifood Systems Model (CAU-AFS Model) with a crop growth model to assess comprehensively the multidimensional impacts of exogenous shocks and policy interventions on domestic food production system.

To capture the impacts of climate change, the study adopts SSP-RCP combined climate scenarios that integrate Representative Concentration Pathways (RCPs) with Shared Socioeconomic Pathways (SSPs). Three representative scenarios are selected, SSP126, SSP370, and SSP585. The climate data come from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP, https://www.isimip.org/). All datasets are bias-corrected and consist of daily meteorological variables at a 0.5°×0.5° latitude-longitude grid resolution.

Gridded crop yield data for corn, soybeans, rice, and wheat are derived from several crop models participating in the Global Gridded Crop Model Intercomparison (GGCMI). The suite includes EPIC-IIASA and PEPIC based on the EPIC framework, pDSSAT based on the DSSAT framework, and models such as LPJmL, ISAM, and LDNDC, all models generate outputs at a spatial resolution of 0.5°×0.5°. In projecting future yields, crop management practices are held at their baseline-period levels to isolate the sole marginal impact of climate change.

On this basis, the simulated impacts of climate change on crop yields from these models are linked to a China-specific computable general equilibrium (CGE) model to analyze cross-sectoral and macroeconomic spillover effects, covering the macroeconomy (GDP) agricultural output, imports, and so on. The CGE model takes 2023 as its benchmark year, with a social accounting matrix (SAM) built on China's 2023 input-output table. The model disaggregates the agricultural sector into 26 sub-industries and incorporates upstream input sectors such as fertilizer and pesticides, distinguishes 15 food-processing sub-sectors, and covers agrifood service segments such as accommodation and catering, yielding a total of 95 sectors. To analyze the effects on food and nutrient supply under the various scenarios, the study further estimates the changes in nutrient supply by mapping simulated food production variations against standardized nutrient content of foods. Given pervasive uncertainty surrounding both shocks magnitudes and intervention effectiveness, the study employs stochastic simulation to characterize uncertainty intervals and to capture more fully the risks the shocks entail.

### 2.4.2 Scenario Design

Building on a benchmark baseline scenario, this study designs two tiers of experimental scenarios: standalone shock scenarios and shock-intervention composite scenarios (summarized in Table 2-2). Because a static model is used, the baseline scenario reflects the actual conditions observed in 2023. The standalone shock scenarios introduce exogenous disruptive factors atop the baseline to examine the independent impacts of multiple risks on the supply of major agricultural products. The composite response scenarios layer policy interventions onto the shock simulations to further quantify the marginal contribution of each measure in enhancing food production resilience.

(1) Baseline scenario

This baseline calibrates the full state of China's agrifood systems as of 2023. In this benchmark year, China's supply of major foods was broadly stable: national grain output totaled 695 million tons, vegetable and edible-fungus output 829 million tons, fruit output about 327 million tons, combined pork, beef, mutton and poultry output about 96.41 million tons, and aquatic-production 71.16 million tons. Domestic output, however, still fell short of total consumption demand. Annual grain imports reached 162 million tons, including 99.41 million tons of soybeans, while meat and aquatic products were imported at 7.38 million and 5.01 million tons, respectively.

In terms of price levels, the producer prices of major agricultural products registered 3,000 yuan/ton for rice, 3,020 yuan/ton for wheat, 2,790 yuan/ton for corn, and 5,340 yuan/ton for soybeans. Livestock commodity prices were recorded at 22,350 yuan/ton for pork, 71,800 yuan/ton for beef, and 63,560 yuan/ton for mutton; vegetable and fruit prices averaged 5,080 yuan/ton and 6,710 yuan/ton, respectively. In macroeconomic terms, GDP stood at about CNY129.4 trillion, agricultural value added at CNY8.9 trillion, and aggregate agrifood systems value added of CNY16.18 trillion, split between food-processing and food catering service value added at CNY2.36 trillion and CNY1.47 trillion, respectively. Domestic food production yielded an energy supply of 3,366 trillion calories, with protein and fat supplies of 115 million tons and 95.4 million tons, respectively.

**Table 2-2 Design of scenario simulations for shocks and policy interventions**

| Scenario Name | Scenario Description | Sources of Scenario Design |
|---|---|---|
| Shock Scenarios | | |
| Climate change shock scenario | Rice yield decreases by 0–10%; wheat by 0–15%; maize by 0–20%; and soybean by 0–15%. | Based on model simulation results for multiple crops, 25 sets of random values subject to extreme negative impacts were selected (Li, 2025). |
| Crop pest and disease outbreak shock scenario | Yields of grain, vegetables, and fruits decrease by 0–10%. | Pests and diseases cause an average crop loss of 9.91%, with losses ranging from 4.84% to 16.29% (Zhang et al., 2022). |
| Livestock epidemic shock scenario | Output of livestock and aquatic products decreases by 0–10%. | Estimated based on the historical impacts of ASF and avian influenza outbreaks. |
| Rising imported input price shock scenario | Import prices of chemical fertilizers and pesticides rise by 5%–125%. | Estimated based on the fluctuations in international fertilizer prices in recent years. |
| Compound shock scenario | Combination of the above scenarios. | —— |
| Shock Scenarios + Policy Interventions | | |
| Climate change shock + agricultural infrastructure & breeding intervention scenario | Under the climate change shock, after infrastructure construction, the yields of rice, wheat, maize, and soybean increase by 0%–10%; breeding increases yields by 0%–5%. | After the construction of high-standard farmland, yield per unit area increases by 10%.[2] |
| Crop pest and disease outbreak shock + prevention & control interventions scenario | Under the crop pest and disease outbreak shock, after prevention and control measures, yields of grain, vegetables, and fruits increase by 0%–5%. | Reference: Horgan, 2021. |
| Livestock epidemic shock + vaccination & biosecurity intervention scenario | Under the livestock epidemic shock, vaccination reduces losses by 90%. | Reference: Liu et al., 2021. |
| Compound shock scenario + comprehensive interventions | Compound shock scenario + combination of the above response measures. | —— |

**Source:** Compiled by authors based on literature and estimates.

[2] 10% Increase! High-Standard Farmland Construction Proves Highly Effective in Safeguarding Grain Output-Policy Interpretation-gov.cn.

(2) Standalone Shock Scenarios

● Climate change shock scenario

This scenario characterizes the impact of extreme weather on agricultural production under different carbon-emission trajectories. The crop model simulations (Figure 2-9) show that under the low-emission scenario (SSP1-2.6), yields of rice, wheat, and soybeans fluctuate only slightly. By contract, under the medium-emission (SSP3-7.0) and high-emission (SSP5-8.5) scenarios, yields of all crops show a clear downward trend, with production losses intensifying as emission levels rise. Crop-specific vulnerability differs markedly: rice is affected relatively modest, mostly capped at 10%; wheat and soybeans fall in the middle range, with maximum yield losses of 15%; and corn is affected the most, with peak yield losses reaching 20%.

● Crop pest and disease outbreak shock scenario.

This scenario isolates the production impacts of large scale of crop pests and diseases outbreak across grain crops, vegetables, and fruits, assuming uniform yield reduction shocks ranging from 0% to 10%.

● Livestock epidemic shock scenario.

This scenario mainly captures output contractions triggered by trans-boundary animal disease in livestock and aquatic products. With reference to the actual incidence of disease over the years, output of livestock and aquatic products is set within a 0–10% range.

● Rising imported input price shock scenario.

This scenario mainly evaluates the impact on food production stemming from steep cost hikes for imported agricultural intermediate goods, principally fertilizer and pesticides. Drawing on the recent price fluctuations of major inputs such as urea, import prices for fertilizer and pesticides are assumed to rise by 5% to125%.

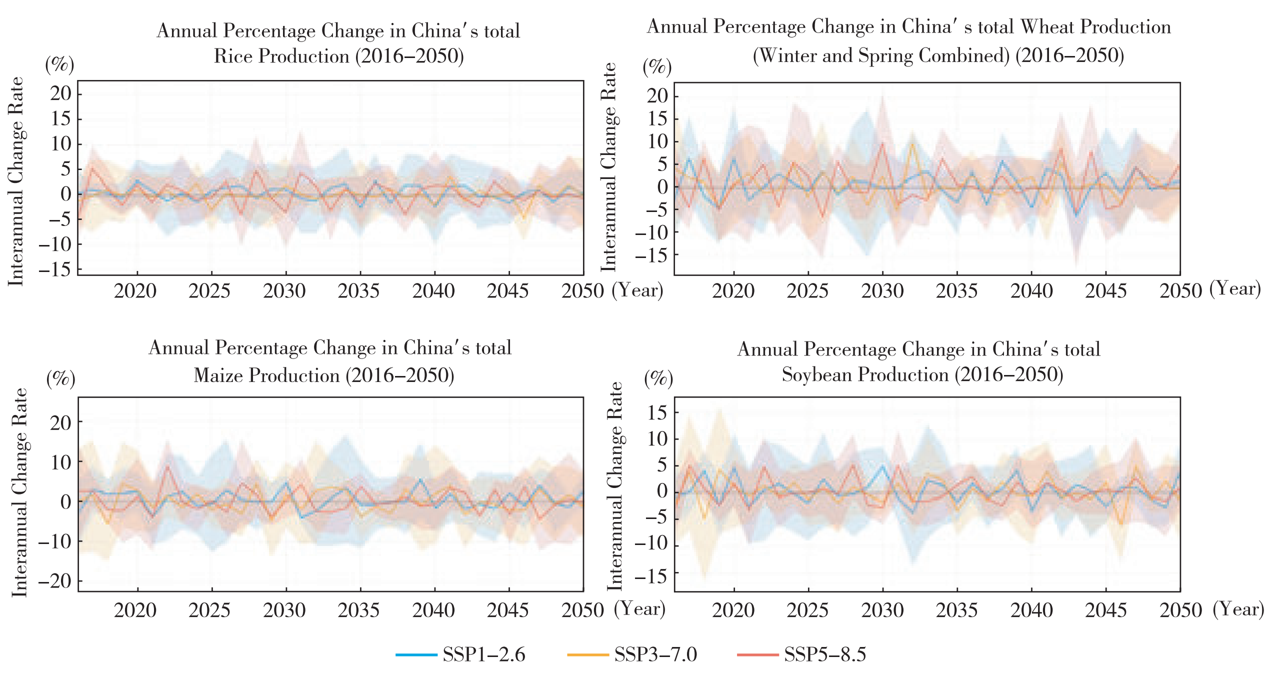
● Compound shock scenario.

This scenario superimposes all four of the above shocks scenarios simultaneously to reflect concurrent overlapping systemic risks.

(3) Policy Intervention Scenarios

Building on the shock simulations, this study incorporates various policy tools into the modeling framework. The analysis focuses on how policy interventions, including high-standard farmland infrastructure, the breeding of drought- and flood-resistant varieties, pest and disease control, vaccine R&D, and bundled response measures, buffer production, prices, and imports, so as to identify the direction and strength of different policy lever in enhancing agricultural resilience.

**Figure 2-9 Impact of climate change on yields of major grain crops in China, 2016–2050**




**Data source:** Ensemble results from crop models based on five GCMs.

### 2.4.3 Quantified Impact of Exogenous Shock and Mitigation Efficacy of Resilience Interventions

External shocks such as climate change, crop pests , and animal diseases are the principal factors that weaken food-production resilience. They not only directly cause production volatility that reshapes agricultural trade patterns, but also transmit food price volatility across the entire supply chain, spread systemic spillover throughout the whole agrifood systems, and ultimately drag down the macroeconomy. The impacts of these shocks on food production also translate directly into fluctuations in nutrients supply. This sub-section therefore analyzes the impacts of external shocks systematically along five dimensions: output (Figure 2-10), imports (Figure 2-11), prices (Figure 2-12), GDP (Figure 2-13), and nutrients supply (Figure 2-14). Each figure separates raw shock outcomes (left panels of Figures 2-10 to 2-14) and the stabilizing effects of resilience-building policy measures (right panels of Figures 2-10 to 2-14).

(1) Impacts of standalone external shocks on food production resilience

● Climate change shock scenario.

Climate change exerts a clearly negative shock on food production overall. Grain output falls by 3.5% to 8% with a median reduction of 4.2%; vegetables and fruits output by 0.8% to 1.5%, meat by 1.5% to 3%, and aquatic products by 1% to 2%. Domestic food output shortage in turn drives broad prices hikes, most markedly for grain: rice rises by 8% to 16%, wheat by 15% to 26%, and corn by 17% to 34%, whereas meat rises edge upward modestly by 2% to 4%. The contraction in domestic supply pushes imports higher, with grain imports rising by 3.4% to 6%. Notably, the combined effect of falling output and rising prices propagate along the industrial chain to hit food processing, catering service, and the national economy as a whole: agricultural GDP declines by 1.2% to 2.6%, while downstream sectors such as food manufacturing and hospitality segments face spiking intermediate input costs and see a more pronounced related GDP decline of 2%, bringing overall GDP down by 1%. Because of climate change's effects on food production, the supply of dietary, protein, and fat also declines, by roughly 2% to 3%.

● Crop pest and disease outbreak shock scenario.

Pests and diseases outbreaks represent a critical risk to food production. Under this shock specification, grain output declines by 0.2% to 5% (median around 2.5%), and vegetables and fruits by 0.16% to 4%. Falling output lifts market prices, yet inflation magnitude is significantly smaller than those simulated under the climate change scenario. Grain prices rise by 1% to 12%, and vegetables and fruits by 0.5% to 11%; meanwhile, under the combined influence of food-price transmission and rising feed costs, livestock-product prices rise modestly, by 0% to 2%. Driven by reduced domestic supply, food imports rise correspondingly, with grain imports increasing by 0% to 2%. From a macroeconomic perspective, the pest and disease outbreak shock affects agriculture and related industries: as rising intermediate input costs combine with suppressed consumption demand, output in agriculture, food processing, and catering sectors declines, in turn weighing negatively on overall GDP. Pest and disease outbreaks affect not only energy supply, which falls by 1% to 2%, but also protein and fat provision, falling by 2% to 3% and 3% to 5%, respectively.

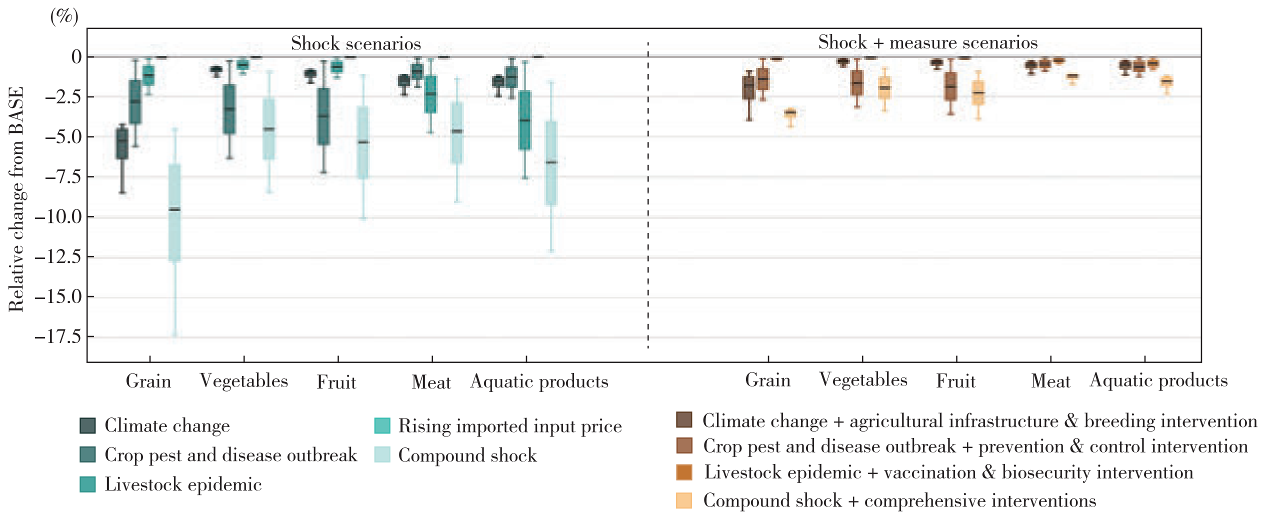
● Livestock epidemic shock scenario.

Animal disease constitutes an important risk factor affecting livestock production. Under a disease shock, meat output declines by 0.12% to 3% and aquatic-product output by 0.2% to 5%. Because consumer demand lacks elasticity, the decline in meat and aquatic-product output drives marked price increases by 0.2% to 7%. As domestic output falls, meat imports rise modestly (median around 0.2%) to fill the domestic supply gap. Higher meat and aquatic-product prices transmit through costs to exert some negative impact on the food industry and the catering sector, though the effect on overall GDP is relatively limited. Animal disease mainly affects the supply of proteins and fat, which fall by 2% to 3%, while energy supply declines slightly.

● Rising imported input price shock scenario.

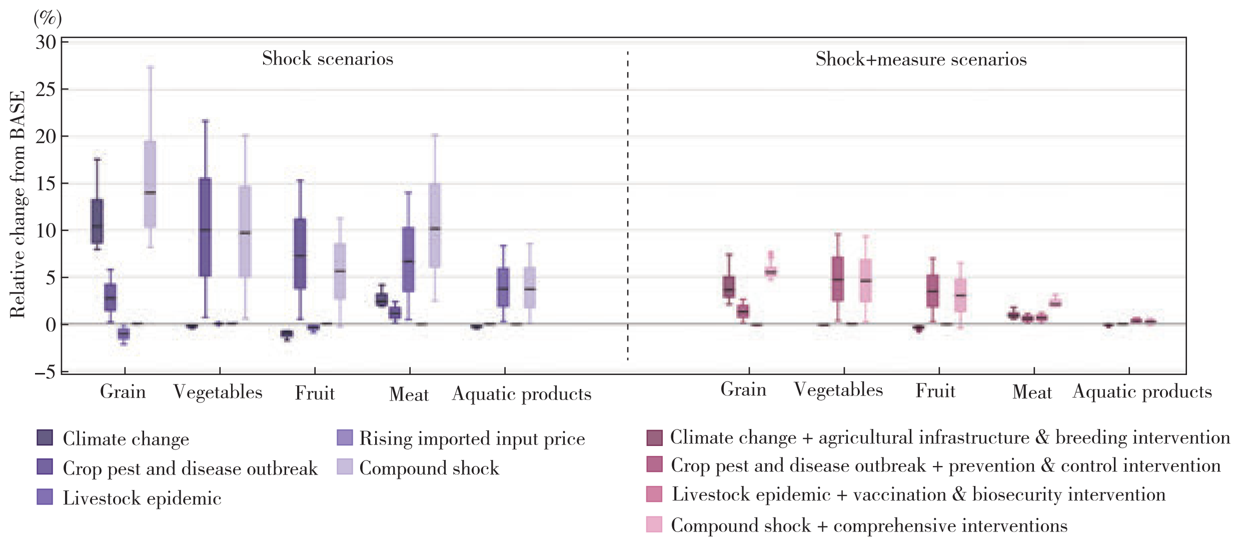
China maintains robust domestic self-sufficiency in fertilizers and pesticides, rendering international input price volatility a comparatively mild threat to domestic food production. With only small changes in output, broad-based food inflation fairs mildly: grain, vegetable, and fruit prices rise merely by 0.02% to 0.2%. Food imports remain largely stable, and the shock to both the agrifood systems and the national economy is fairly limited. Corresponding nutrients shifts are constrained

**Figure 2-10 Changes in output of major agrifood products in China under different scenarios**



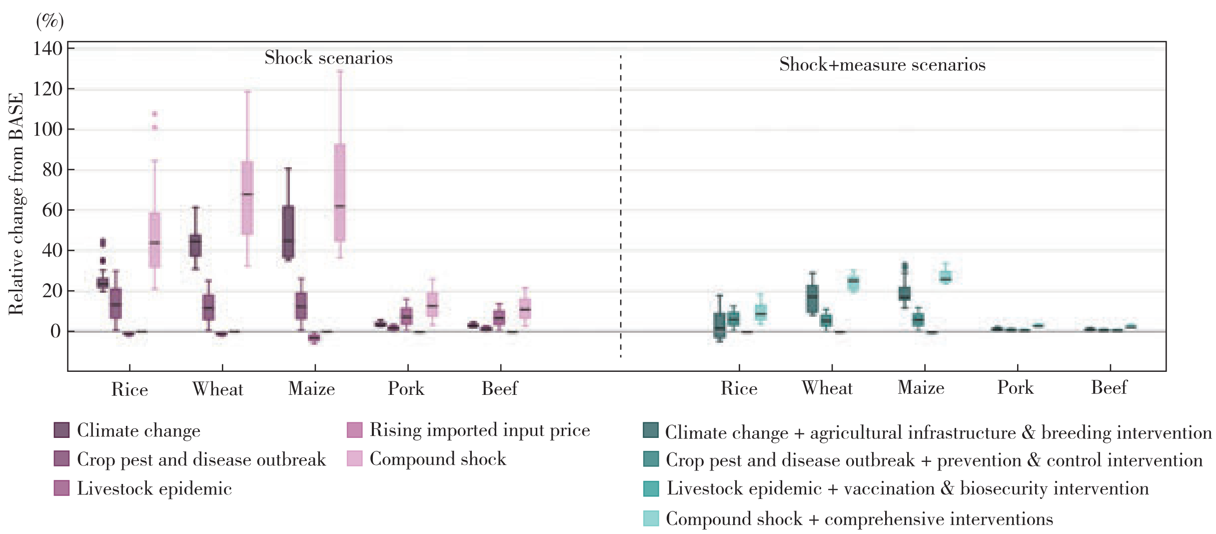

**Source:** Results from the China Agricultural University Agrifood System Model (CAU-AFS Model).

**Figure 2-11 Changes in imports of major agrifood products in China under different scenarios**



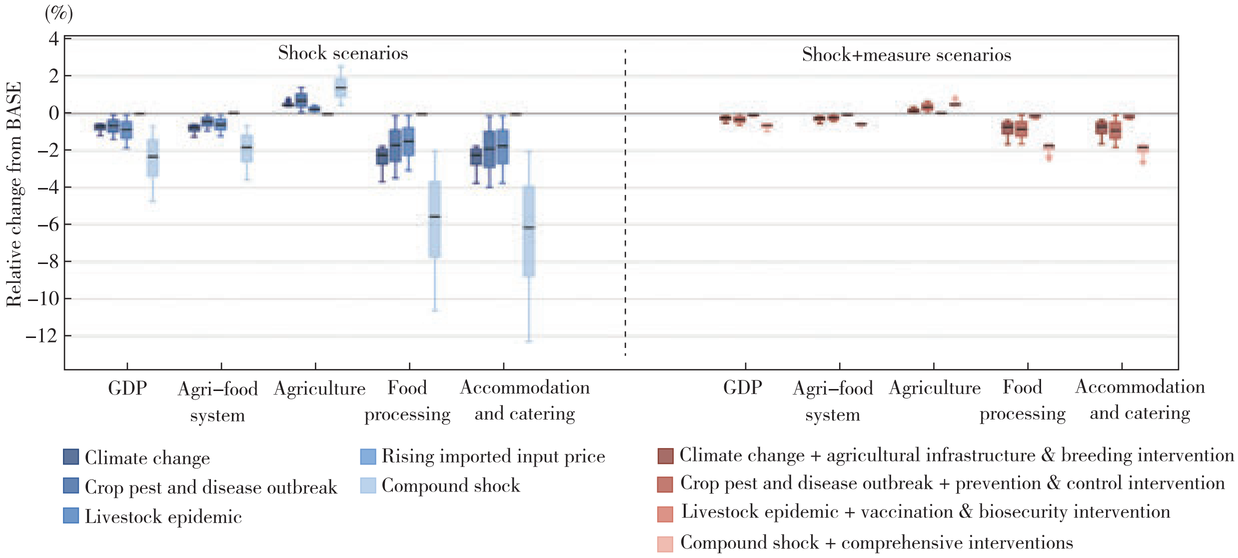

**Source:** Results from the China Agricultural University Agrifood System Model (CAU-AFS Model).

**Figure 2-12 Changes in prices of major agrifood products in China under different scenarios**



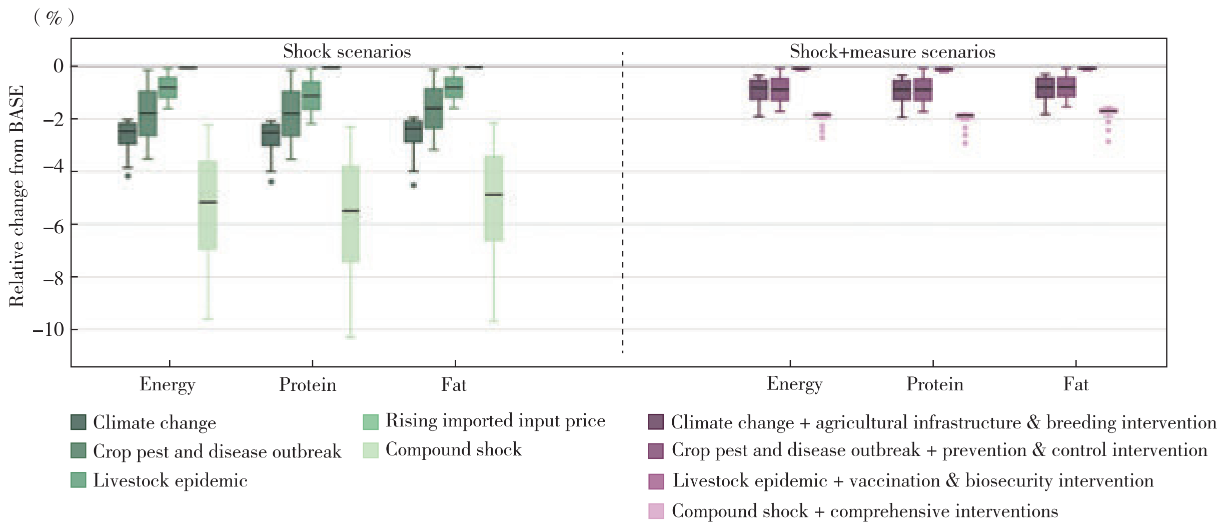

**Source:** Results from the China Agricultural University Agrifood System Model (CAU-AFS Model).

**Figure 2-13** Changes in agricultural GDP and agrifood system GDP in China under different scenarios




**Source:** Results from the China Agricultural University Agrifood System Model (CAU-AFS Model).

**Figure 2-14** Changes in nutrients supply in China under different scenarios




**Source:** Results from the China Agricultural University Agrifood System Model (CAU-AFS Model).

within a 1% range.

● Compound shock scenario.

This extreme scenario superimposes all four standalone hazard categories to stimulate full systemic risks exposure to food production. The simulations show synchronized production contractions across all food types: grain falls by 4% to 14%, vegetables by 1% to 6%, fruits by 1% to 7%, meat by 2% to 9%, and aquatic products by 1.5% to 10%. Falling output drives sharp price increases: grain prices surge by 13% to 47%, vegetables and fruits by 0% to 10%, and meat and aquatic products by 2% to 14%. As domestic prices climb, grain imports rise by 3% to 8%. Higher food prices raise costs, affecting GDP in agriculture, food processing, and accommodation and food service, which falls by 5%–6%, while overall GDP declines by 2%. The impact on food nutrient supply is also pronounced, with the supplies of energy, protein, and fat each declining by 5%–10%.

(2) Mitigation Efficacy of Resilience Building Interventions

● Climate change shock + agricultural infrastructure & breeding intervention scenario.

When pairing the climate change shock with dual adaptive interventions, including high-standard agricultural infrastructure construction and stress-resistant improved variety, food production resilience improves markedly, and the adverse effects of the climate shock are effectively offset. The decline in grain output narrows to 0.5%–3% (median around 1.5%), the declines in vegetable and fruit output are largely capped within 1%, and the contractions in meat and aquatic-product shrink to 0.3%–1.3%. Inflation in agricultural prices also ease markedly: grain price increases ease to 2%–12%, well below those under the climate-shock scenario, with rice price rising 2%–7% and wheat and corn price 4%–16%; price changes for vegetables, fruits, and livestock products all confined within a 2% band. On trade margins, grain import growth drops noticeably to 1%–3%, while negligible shifts in imports of vegetables, fruits, and meat (below 1%).

The climate adaptation measures also effectively ease the adverse macroeconomic impacts of external shocks, curbing output declines in downstream sectors such as food processing and catering and delivering systemic resilience gains across the agrifood value chain. As output recovers, the median nutrients supply losses for energy, protein, and fat to below 1%, leaving mild overall food nutrient disruption.

● Crop pest and disease outbreak shock + prevention & control interventions scenario.

When layered onto pest and disease outbreaks, integrated crop protection intervention markedly reduce agricultural yield losses. The decline in grain, vegetable, and fruit output narrows to 0.1%–2%. The recovery on the supply side suppress commodity inflation: grain prices rise narrow to 0%–6% and vegetable and fruit prices to 0%–5%, and more stable grain prices also help stabilize livestock product prices (within 3%). As the decline in domestic output narrows significantly, the increase in grain imports falls to within 1%. The food-processing and catering sectors still face cost-increase pressure, but it is markedly weaker. The declines in all three food nutrients also shrink significantly, with energy and protein supply reduction narrowing to around 1%.

● Livestock epidemic shock + vaccination & biosecurity intervention scenario.

When the animal disease shock is combined with vaccination and control measures, the resilience of livestock production improves markedly. Output declines for meat and aquatic products narrow to within 0.6%, while output of grain, vegetables, and fruits remain unaffected. Price increases also shrink noticeably, with both meat and aquatic-product prices increase capped at 1%. Meat imports likewise revert to baseline levels. The vaccination and control interventions effectively block the impact of animal disease risk on the agrifood systems, leaving overall GDP largely undisturbed. These measures have a clear effect in stabilizing food nutrient supply, with the median supply decline for energy, protein and fat are all fall below 0.2%.

● Compound shock scenario + comprehensive interventions.

Under the scenario combining the compound shock with cross-cutting intervention framework, the measures can mitigate the adverse effects of the shock partially yet fail to fully reverse systemic downward pressures. Specifically, food output still declines broadly, imports rise passively, prices maintain upward trajectories, and the downstream food-processing and catering sectors, as well as agrifood systems GDP sustain negatively affected. Grain output declines by 2%–5%, while vegetables and fruits, meat, and aquatic products output losses hover within a 1%–2% range. Major food prices still trend upward overall: grain prices rise 7%–12%, with rice by 2%–8%, wheat by 10%–15%, and corn by 12%–17%, and meat price climb 2%–3%. The bundled measures can hedge price volatility to some degree, but they cannot fully offset the upward price pressure triggered by overlapping shock.

Food imports decline markedly relative to the shock scenario, with grain import increase falls to 1%–3% and fruit and meat imports increments narrowing to within 0.5%. The macroeconomy headwinds persist: GDP in the food-processing and catering sectors declines by 2%, agrifood systems GDP by 2%, and overall GDP by 1%. While the comprehensive interventions cannot fully offset the compound shock's impact, they keep the overall loss in the supply of energy, protein, and fat within a 2% threshold, significantly enhancing the agrifood systems' resilience in safeguarding food nutrition.

## 2.5 Conclusions and Policy Recommendations

Drawing on multidimensional historical data on China's major food output, nutrient supply, and prices, this chapter systematically assesses the overall level and structural features of food production resilience. It further simulates the effects of different risk scenarios on food production, trade, prices, the macroeconomy, and nutrition security, as well as the potential roles of different policy interventions. The core findings and policy recommendations are summarized as follows.

### 2.5.1 Key Findings

First, China's food production remains broadly stable overall, but follows a pattern of "stable in aggregate, divergent in structure," with resilience differing markedly across products and regions. Nationally, the total output of staple foods holds steady, and grain production rests on a fairly solid foundation; yet output at the provincial level fluctuates considerably, especially for cash crops and certain livestock products, where the swings are wider. The overall supply of food nutrients is relatively sufficient, but protein and fat supply is more prone to periodic fluctuations. Prices of staple grains are relatively stable, whereas cash crops and livestock markets experience severe price turbulence, with pork price volatility being especially pronounced.

Second, risks such as climate change, pest and disease outbreaks, and animal diseases have a significant impact on food production, but they differ markedly in transmission channels and damage severity, calling for differentiated and targeted responses. Climate change affects production system-wide, hitting field crops such as grain hardest: it not only cuts output, drives up prices, and raises imports, but also transmits through the industrial chain to downstream sectors such as food processing and catering. Pests and diseases mainly affect the supply of crop-farming products such as grain, vegetables, and fruits, while animal diseases chiefly hit livestock and aquatic supply and push up prices of the related products through the cost transmission mechanism.

Third, the impact of any single risk shock is relatively limited, whereas multiple risks compounding one another sharply amplify systemic risk. Compared with standalone shocks, a compound shock scenario reaches wider and lasts longer across the agrifood systems, fully exposing structural fragility to compound risks. Under the compound shock scenario, overlapping hazards trigger synchronous yield decline across grains, vegetables, fruits, meat, and aquatic products, widespread sharp price rises, and a marked increase in imports. The combined shocks also impose severe negative impacts on food-processing industry, catering service, and the national economy as a whole.

Fourth, existing policy measures can substantially buffer the effects against isolated food production shocks, but fail to fully offset the adverse effects of long-term compound risks. Measures such as high-standard farmland construction, improvedvariety breeding, pest and disease control, and vaccination can all effectively narrow output declines, slow price increases, and reduce import dependence. Among these, infrastructure upgrades and breeding innovation do the most to stabilize grain production, while pest and disease control and vaccination stand out in stabilizing the supply of vegetables, fruits, and livestock products. However, under the compound shock scenario, even with comprehensive measures in place, food output still falls markedly, prices keep climbing, and the agrifood systems' related industries and overall GDP still take a sizable hit. This shows that existing measures can serve as an important short-term risk buffers yet remain insufficient to fully hedge the challenges posed by long-term systemic risks.

### 2.5.2 Policy Recommendations

Looking ahead, against a macro backdrop of rising uncertainty, China's food production will face shocks from multiple risks spanning climate change, pest and disease outbreaks, animal diseases, resource and environmental constraints, and volatility in input prices over long run. These risks affect not only food production but also transmit disruptions to trade, food processing, and catering sectors, ultimately challenging the resilience of food supply on the consumption side. There is therefore imperative to coordinate short-term emergency management with long-term adaptive capacity building, and to shift resilience governance toward a "whole-process risk management" paradigm. Grounded in the chapter's main conclusions, four targeted policy recommendations are proposed as follows.

**(1) Build a multidimensional food production resilience monitoring to improve the capacity for precision governance.** Given that food output is stable in aggregate yet fluctuates considerably at the provincial level, with resilience varying widely across categories, this study recommends establishing a three-dimensional monitoring system structured along the dimensions of region, product and risk. Prioritized oversight should cover the key provinces, major products, and major risks. The focus of monitoring should be refined from the national aggregate down to key provinces, main producing areas, and vulnerable producing areas, with close tracking of changes in output, sown area, stocks, distribution, prices, and imports to avoid masking underlying differences. Differentiated, dynamic surveillance mechanism shall be applied for staple grains, vegetables and fruits, livestock and aquatic products, with particular attention to categories that show large output swings, fast price transmission, or high nutrition contribution. Cross-departmental data integration and information sharing shall be advanced across meteorological, plant-protection, disease-prevention, water-conservancy, and market information, to improve the capacity for early warning and accurate assessment of extreme weather, major pest and disease outbreaks, and abnormal market fluctuations.

**(2) Deploy differentiated measures to address resilience vulnerabilities and strengthen the system's risk resistance.** While consolidating grain production as the core anchor of national food security, policy priority shall be allocated to resilience enhancement for highly volatile products such as vegetables and fruits, livestock products, and aquatic products to narrow structural resilience gaps. For vegetables and fruits, scaled-up green prevention and control of pests and diseases in vegetables and fruits, as well as cold-chain storage and distribution systems, shall reduce seasonal and regional supply fluctuations. In livestock farming, resilience-building priorities encompass animal disease monitoring, the development of new vaccines, farm biosecurity, restocking and resumption of breeding, and aquatic disease prevention and control, to comprehensively improve the stability and safety of animal protein supply.

**(3) Improve short-term shock response frameworks and mitigate unintended distortion from emergency policy instruments.** A single risk shock, if mishandled, can easily turn into a long-term loss of production capacity, so the full-chain emergency response mechanism of pre-disaster warning, in-disaster disposal, and post-disaster recovery, should be further improved. In crop farming, authorities shall upgrade support mechanisms for post-disaster replanting, crop restructuring, emergency input stockpiling, cross-regional allocation, mechanized services, and targeted agronomic guidance, thereby enabling rapid recovery of acreage and sustained yields after disruptive events. In livestock farming, comprehensive measures packages including disease handling, harmless disposal, restocking and resumption of breeding, capacity monitoring, and market regulation should be strengthened to prevent transient disease outbreaks from turning into sustained capacity losses. Concurrently, policymakers shall enhance the timeliness of targeted agricultural insurance enrolment and indemnity settlement, emergency agricultural credit provision, input subsidy disbursement, and supply-demand matching services to minimize adverse short-term shock impacts.

Additionally, policymakers must guard against latent distortions generated by temporary emergency tools, including fiscal subsidies, price support programs and trade protection measures, which may hinder long-term system restructuring and the development of core sector competitiveness. All emergency interventions should be embedded with explicit sunset provisions and orderly withdrawal mechanisms to avoid permanent policy lock-in, thereby reconciling the dual objectives of short-run supply stability and long-term high-quality development of agrifood systems.

**(4) Strengthen long-term comprehensive capacity building to lay a solid foundation for the resilience strategy.** To cope with compound, long-term risks, it requires prioritizing the cultivation of long-term systemic adaptive capacity as a core strategic agenda. On infrastructure, sustained progress should be made in constructing high-standard farmland, upgrading farmland water conservancy facilities, and implementing agricultural disaster prevention and mitigation projects. Policy and resource inclination should be further strengthened toward major grain-producing regions, areas dominated by medium- and low-fertility farmland, and territories highly vulnerable to climate hazards. On science and technology innovation, continuous R&D efforts should focus on the development of drought-resistant, waterlogging-tolerant, pest- and disease-resistant, nutrition enhanced and stable- and high-yield varieties, as well as animal vaccines. Meanwhile, scalable promotion should be granted to green pest management, digital agriculture, intelligent monitoring and precise epidemic prevention technologies. On biosecurity governance, strict on-farm biosecurity supervision and cross-regional joint epidemic monitoring and control mechanisms should be consolidated to systematically mitigate the prevalence and spillover risks of agricultural diseases and pests.

## References


TIAN K, YU X, ZHAO T, et al. Emergence of fatal PRRSV variants: Unparalleled outbreaks of atypical PRRS in China and molecular dissection of the unique hallmark[J]. PLoS ONE, 2007, 2(5): e526.

TONG G Z, ZHOU Y J, HAO X F, et al. Highly pathogenic porcine reproductive and respiratory syndrome, China[J]. Emerging Infectious Diseases, 2007, 13(9): 1434-1436.

LEI J, MIAO Y, BI W, et al. Porcine epidemic diarrhea virus: Etiology, epidemiology, antigenicity, and control strategies in China[J]. Animals, 2024, 14(2): 294.

SPACKMAN E. A brief introduction to avian influenza virus[J]. Methods in Molecular Biology, 2020, 2123: 83-92.

LOBELL D B, SCHLENKER W, COSTA-ROBERTS J. Climate trends and global crop production since 1980[J]. Science, 2011, 333(6042): 616-620.

LENG G, HALL J. Crop yield sensitivity of global major agricultural countries to droughts and the projected changes in the future[J]. Science of the Total Environment, 2019, 654: 811-821.

XIAO L, WEI X, WANG C, et al. Plastic film mulching significantly boosts crop production and water use efficiency but not evapotranspiration in China[J]. Agricultural Water Management, 2023, 275: 108023.

HUANG T, WU Q, YUAN Y, et al. Effects of plastic film mulching on yield, water use efficiency, and nitrogen use efficiency of different crops in China: A meta-analysis[J]. Field Crops Research, 2024, 312: 109407.

TU D, JIANG Y, LIU M, et al. Improvement and stabilization of rice production by delaying sowing date in irrigated rice system in central China[J]. Journal of the Science of Food and Agriculture, 2020, 100(2): 595-606.

ZI S, LI Y, ZHANG J, et al. The biophysical and crop yield effects of irrigation and their changes in China's drylands[J]. Agricultural Water Management, 2025, 313: 109471.

LI J, NIE B, GAO L, et al. Modelling for assessing the compulsory vaccination strategy against highly pathogenic avian influenza in a poultry farm of China[J]. Applied Mathematical Modelling, 2025, 145: 116130.

WANG L, HE L, ZHU X, et al. Large-area field application confirms the effectiveness of toxicant-infused bait for managing Helicoverpa armigera (Hübner) in maize fields[J]. Pest Management Science, 2023, 79(12): 5405-5417.

ZHANG Q, MEN X, HUI C, et al. Wheat yield losses from pests and pathogens in China[J]. Agriculture, Ecosystems & Environment, 2022, 326: 107821.

FREZAL C, GAY S H, NENERT C. The impact of the African Swine Fever outbreak in China on global agricultural markets[R]. OECD Food, Agriculture and Fisheries Papers, No. 156. Paris: OECD Publishing, 2021.

GUO Y Y, YUE K, ZHANG X, et al. Effects of co-infection factors on the pathogenicity of porcine epidemic diarrhea virus[J]. Acta Veterinaria et Zootechnica Sinica, 2026, 57(3): 1334-1347. https://link.cnki.net/urlid/11.1985.s.20260113.1428.010.

JIANG T, WANG Y M. Bibliometric analysis of research literature on African swine fever virus based on the Web of Science database[J]. Acta Editologica, 2019, 31(S2): 308-310.

SU G F, HUA J G, SUN W S, et al. Formation mechanism and empirical test of the nonlinear impact of swine epidemics on pork prices[J]. Chinese Rural Economy, 2021(11): 107-124.

SUN Y X, WANG J H, SHEN G M. Emergency response measures for sudden outbreaks of foot-and-mouth disease Asia type I[J]. Modern Animal Husbandry and Veterinary Medicine, 2005(8): 29-30. https://kns.cnki.net/kcms2/article/abstract?v=kn2pS-460sONdXdYVe0IOd23guqUBkjlKcZVmkTN-3l4r-f-MMnGdHxvrhMvKbmUWapWRSq2hGCHxxQ-mibBzfKwlBwwI7g6uEzy5cSJqW2zJh2W0miXsKLV-jtC7rYsM992-YKlagGD3yzrzAp7IBpV-bLfF7r8Agtqvl-CjluNdCdLTxAUxvVv0fA==&uniplatform=NZKPT&language=CHS.

ZHANG T, ZHANG J H, LIAO M, et al. Epidemic trends of avian influenza and current status of vaccine research in China[J]. China Poultry, 2025, 47(5): 141-151.

HUANG X, HAN M L, ZHANG X X, et al. Analysis of the epidemiological situation and current status of foot-and-mouth disease in China since 2010[J]. Heilongjiang Animal Science and Veterinary Medicine, 2018(6): 80-83, 240.

LI S L, YAO K, CAO Z J, et al. National dairy industry technology system: 2015 technical development report on the dairy cattle industry[J]. Chinese Journal of Animal Science, 2016, 52(2): 34-39.

WU J H, ZHOU M H, FENG M, et al. Research progress on genes related to resistance to bovine mastitis[J]. Chinese Journal of Animal Science, 2026, 62(2): 68-78. DOI: 10.19556/j.0258-7033.20250303-07.

ZHANG J H, LIU X Y, CHEN B O. Public health emergencies, migrant-worker mobility and the agricultural labor reservoir: Micro evidence based on China Family Panel Studies data[J]. Journal of Finance and Economics, 2023, 49(8): 64-78.
ZHOU D L. The "three rural" issues in building a harmonious society[J]. Contemporary World and Socialism, 2005(6): 90-94.
WANG X, XIN X F, ZHANG Y, et al. Evolutionary characteristics of import and export trade trends of chicken products in China and countermeasures for industrial development[J]. Chinese Journal of Animal Science, 2025, 61(5): 423-428.
HAN Z, HU X D, SHI Z Z. Analysis of China's African swine fever prevention and control policies and optimization strategies[J]. Chinese Journal of Agricultural Resources and Regional Planning, 2023, 44(3): 11-17.
ZHAO L G, HUO Y J. New quality productive forces empowering the improvement of agricultural economic resilience: Mechanism analysis and promotion paths[J]. Journal of Hubei University (Philosophy and Social Sciences), 2025, 52(1): 164-173.
YAN Q. Study on the interactive relationship between rural labor mobility and agricultural development[J]. Agricultural Machinery Using & Maintenance, 2024(8): 62-64.
LIU J X, LIN Q, FAN X C. Impact of major public crises on consumers' panic buying[J]. Collected Essays on Finance and Economics, 2024(8): 100-110.
FENG M L, LUO X F, DAI M T, et al. Impact of risk shocks on farmers' cultivated-land quality protection behavior[J]. Journal of Arid Land Resources and Environment, 2026, 40(2): 167-176.
MAO W, SU S, CHEN M, et al. Research progress on the connotation analysis and evaluation index system construction of cultivated land quality[J]. Journal of Plant Nutrition and Fertilizers, 2025, 31(11): 2133-2155.
YANG M J, WU S, YU Y D, et al. Research history and prospects of agricultural water-saving irrigation evaluation[J]. Journal of China Institute of Water Resources and Hydropower Research, 2016, 14(3): 210-218.
LI W G, MA Z F, LI J, et al. Review of comprehensive evaluation methods for high-standard farmland construction[J]. Journal of Chinese Agricultural Mechanization, 2025, 46(12): 215-221.
LI T X, XU Y S, ZHU J. Construction of China's agricultural disaster prevention and mitigation system: Achievements, problems and suggestions[J]. Journal of Shanxi Agricultural University (Social Science Edition), 2023, 22(6): 43-52.
MA J L, KONG W S, ZHU T H. Characteristics and impacts of agricultural disasters and mechanisms for disaster prevention, mitigation and resistance: A literature-review perspective[J]. Journal of China Agricultural University (Social Sciences), 2020, 37(5): 122-129.
ZENG Y Z, MU Y Y. Analysis of the advantages of agricultural insurance in agricultural risk management[J]. Agricultural Economy, 2011(5): 51-53.
WANG G M, ZHOU Q Y. Study on risk-diversification mechanisms for agricultural natural disasters[J]. Seeker, 2008(1): 48-50.
GUO J, QIAN H. Advantages and countermeasures of weather-index insurance for agricultural risk management[J]. Heilongjiang Grain, 2025(5): 48-50.
CHEN X. Agricultural meteorological disaster insurance and the construction of agricultural disaster prevention and mitigation capacity[J]. Journal of Agricultural Catastrophology, 2023, 13(8): 308-310.
ZHAO S J. Promoting the construction of risk model systems and strengthening risk management in agricultural insurance[J]. Agricultural Outlook, 2023, 19(6): 77-87.
JIANG Q Y, LIU S G. Responsibilities of provincial, autonomous-region and municipal local governments in agricultural natural disaster prevention and relief in China[J]. Journal of Anhui Agricultural Sciences, 2011, 39(25): 15349-15351.
Strengthening emergency management of major agricultural natural disasters[J]. China Agricultural Information, 2006(3): 21.
LIU S R, CHEN Y Q, NIE X Q, et al. Effects of tree species diversity on forest ecosystem multifunctionality and resilience[J]. Scientia Silvae Sinicae, 2026, 62(1): 1-18.
HE J J, HE Y, YU W, et al. Research progress on flexible wearable biosensors for early warning of crop stress and diseases and pests[J/OL]. Biotechnology Bulletin, [2026-01-23]. https://doi.org/10.13560/j.cnki.biotech.bull.1985.2025-0911.
ZHAO P P, HUANG Z Y, JI K Y, et al. Intelligent identification and monitoring technologies for diseases and pests and their application strategies in the context of smart forestry[J]. Rural Scientific Experiment, 2026(1): 150-152.
SHI Y X, LU Y, SI X Y, et al. AW-KG: A knowledge graph construction method for rice diseases and pests based on large language models[J/OL]. Computer Engineering and Applications, 1-17[2026-05-28]. https://link.cnki.net/urlid/11.2127.TP.20260107.1427.004.
HAO X, ZHOU Z Y, SONG Y, et al. A wheat disease and pest recognition method based on a lightweight multimodal Blend-CNN model[J]. Transactions of

the Chinese Society for Agricultural Machinery, 2025, 56(12): 490-498, 559.
LUO X, JIANG S Q, XIAO G S, et al. Research progress in biological control of rice sheath blight[J/OL]. Microbiology China, [2026-01-23]. https://doi.org/10.13344/j.microbiol.china.250964.
LAN Y B, WANG C F, SUN H G, et al. Low-altitude technology empowering smart agriculture: Technical systems, application scenarios, challenges and suggestions[J]. Smart Agriculture, 2025, 7(6): 18-34.
ZENG K F, ZHANG P C, WANG L, et al. Lightweight recognition method for tea diseases and pests based on improved YOLOv11n[J]. Transactions of the Chinese Society of Agricultural Engineering, 2025, 41(24): 220-229.
SONG X L, ZHANG F, WU H R, et al. Lightweight detection of major diseases and pests in Shandong tobacco-growing areas based on semi-supervised learning and improved YOLOv8n[J]. Acta Tabacaria Sinica, 2026, 32(1): 122-134. DOI: 10.16472/j.chinatobacco.2025.T0130.
GAO Y F, MOU Y, CHEN W Z. Research progress on the application of computer vision technology in rice[J/OL]. Journal of the Chinese Cereals and Oils Association, [2026-01-23]. https://doi.org/10.20048/j.cnki.issn.1003-0174.001282.
WU H Y, CHEN M, GUO Q H. Expert system for rice diseases and pests based on large language models and knowledge graphs[J]. Transactions of the Chinese Society of Agricultural Engineering, 2025, 41(22): 244-255.
YANG L, ZHANG X K, CHEN A W, et al. Effects of rapeseed varieties, overwintering regulation and disease and pest control on the yield of direct-seeded rapeseed[J]. Scientia Agricultura Sinica, 2025, 58(21): 4333-4345.
JIANG X S, RONG Z F, HUANG L F, et al. Research progress on modern technologies for monitoring and early warning of forest diseases and pests[J]. Journal of Agricultural Science and Technology, 2025, 27(1): 1-16.
QIU R Z, CHEN S P, ZHAO J, et al. Construction and application of a rapid pesticide query system for crop disease and pest control[J]. Chinese Journal of Pesticide Science, 2022, 24(3): 630-636.
LIANG X H, WU Y, ZHOU A L, et al. Diffusion pattern of agricultural science and technology policies and path optimization in the new era[J]. Research of Agricultural Modernization, 2025, 46(3): 397-412.
CHEN X J, FU Y C. Evolutionary trajectory and theoretical logic of China's agricultural green transformation support policies: A textual analysis based on the No. 1 Central Documents from 2004 to 2023[J]. Ecological Economy, 2025, 41(2): 120-127.
LI X X, HU Y H. Exploration of biological agriculture from the perspective of building an agricultural power: Implications, characteristics, policy dynamics and practical paths[J]. Rural Economy, 2026(1): 88-97.
GAO Q, CHEN H Y, ZHANG X L. Historical evolution and focus characteristics of China's agricultural green development policies: A textual analysis from the attention perspective[J]. Resources Science, 2023, 45(12): 2433-2448.
SUN Y, MA R Z, LIANG Y W, et al. Effects of agricultural subsidy policies on green production based on meta-analysis[J]. Journal of Systems & Management, 2025, 34(1): 137-151.
WANG D R. Financial support for agricultural science and technology innovation from the perspective of new policies: An investigation from Longnan, Gansu Province[J]. Journal of Shanxi University of Finance and Economics, 2013, 35(S1): 34.
ZHANG X M, XU C X, ZHANG J Q, et al. Demand effects for new-quality laborers in the implementation of smart-agriculture policies: Empirical evidence based on generative AI big data mining[J]. Chinese Rural Economy, 2025(12): 63-83.
Monthly report on international agricultural product market prices and trade situation (No. 49)[J]. World Agriculture, 2025(12): 128-131.
YU R. The impact of multidimensional external shocks on wholesale prices of agricultural products[D]. Shenyang: Shenyang Agricultural University, 2025.
AN H L. Research on the dairy price mechanism in Inner Mongolia from the perspective of the industrial chain[D]. Hohhot: Inner Mongolia Agricultural University, 2025.
YANG S. Reflections on grain market monitoring and early warning in Guizhou Province[J]. Grain Issues Research, 2025(2): 53-56.
XU L, ZHU J, WANG X J. Transformation plan and economic impact of China's domestic grain support policies under open conditions[J]. Journal of Nantong University (Social Sciences Edition), 2025, 41(1): 86-99.
CONG L, LIU R T, QI J, et al. Analysis, assessment and countermeasure suggestions for the current pig-to-grain price ratio situation in Hebei Province[J]. Journal of Hebei Agricultural University (Social Sciences), 2023, 25(6): 107-115.
YANG Q F. Measurement and mechanism of agricultural resilience in Northeast China[D]. Changchun: University of Chinese Academy of Sciences (Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences), 2023.
CAO B M, HUANG H S, ZHAO X. Evolutionary logic, prac-

tical contradictions and optimization path of China's grain reserve system[J]. Issues in Agricultural Economy, 2022(11): 25-33.

TIAN Q S, YU Y, LI C G. Impact of the minimum purchase price policy on market price expectations for rice in China[J]. Journal of Huazhong Agricultural University (Social Sciences Edition), 2022(5): 114-122.

WANG X Y. Embedding big data in price regulation and optimizing regulatory tools[J]. Macroeconomic Management, 2020(2): 66-72.

WANG W B. Reflections on early warning and regulation of China's live pig market prices: Precise supply-side reform of live pig production based on a typical investigation of the generalized pig-to-grain price ratio[J]. Price: Theory & Practice, 2017(5): 49-52.

XIONG W, QI C J. Early warning of market price risks for fruit and vegetable agricultural products[J]. Price: Theory & Practice, 2016(12): 41-44.

GAO H Y, HU X P. Current status and optimization of the variety-structure layout of government grain reserves in China[J]. Journal of Sichuan Normal University (Social Sciences Edition), 2023, 50(5): 84-91.

ZOU J W, WANG W W, ZHANG Y J, et al. Breeding and efficient cultivation techniques of the new drought- and saline-alkali-tolerant wheat variety Cangmai 17[J]. Science & Technology Review, 2025, 43(19): 69-75.

## Chapter 3

# Strengthening Resilience of Intermediate Links: Capacity Building and System Upgrade of the Agrifood Supply Chain


**CHEN Yuquan[1], WANG Ziwen[1], LIN Faqin[1], CHEN Hongsong[1], DENG Tai'an[2], WU Zongyi[3], TAN Fuli[4], and XUE Li[1]**

1. Academy of Global Food Economics and Policy, China Agricultural University
2. Institute of Agricultural Economics and Information, Guangdong Academy of Agricultural Sciences
3. Fuzhou University
4. School of Economics and Management, Xinjiang Vocational University of Technology

### Key Findings

● Intermediate links serve as the core pillar of agrifood system resilience. Warehousing and logistics, food processing, international trade and retail together form the critical chain connecting farmland to dining tables. The effective operation of this chain amid shocks directly determines food accessibility, nutrition security and price stability, making it an integral part for resilience building.

● While the resilience of China's intermediate links has improved steadily, prominent structural weaknesses remain 2013 to 2024, China made marked progress in cold-chain logistics and emergency support systems. Nevertheless, fundamental issues persist, including excessive concentration of import sources for key commodities such as soybeans, insufficient overseas warehousing layout, and sustained profit compression among food processing enterprises.

● Escalated geopolitical risks have considerably hindered China's efforts to secure food supply from global markets. Deteriorating stability of major shipping lanes, weakening binding force of trade rules and growing policy uncertainties in major supply countries pose risks of import channel disruptions. Sharp rise in transportation costs driven by geopolitical conflicts further limits the room for offsetting domestic supply shortages through imports.

● Digital retail has improved supply efficiency yet introduced new types of systemic risks. Challenges including high market concentration of platforms, biased algorithm-based distribution and cyber security threats have become increasingly evident. Operational fluctuations or technical failures of leading platforms can trigger shocks that spread rapidly across supply chains. Inadequate delivery coverage in rural areas and the high cost for vulnerable groups to access nutritious food further expose major deficiencies in the resilience guarantee of end retail.


## Policy Recommendations

● Establish a globalized warehousing and logistics network to enhance frontline buffering capacity for cross-border supply. Deploy overseas warehouses and transit facilities in major grain-producing regions and key shipping hubs to gain response time amid shipping disruptions. Integrate data from ports, railways and highways to build a multimodal transport dispatching platform, which enables rapid switching to alternative routes and sustains the smooth operation of cross-border logistics when regular transport corridors are blocked.

● Improve the flexible production capacity of the food processing industry to consolidate the industrial foundation for emergency supply guarantee. Develop modular production lines and digital process systems, allowing enterprises to swiftly shift production to staple and emergency foods in case of raw material shortages or surging demand. Meanwhile, improve food safety traceability and information disclosure mechanisms to maintain consumer confidence in processed foods and ensure their effective role as alternative supplies during emergencies.

● Diversify import sources of agricultural products in a systematic manner and strengthen institutional arrangements for trade security. Expand procurement channels from emerging supply countries to reduce excessive reliance on a handful of nations for key commodities such as soybeans. Take an active part in regional cooperation mechanisms for emergency grain reserves, and promote the inclusion of trade continuity clauses in bilateral and multilateral agreements, so as to provide more robust institutional safeguards for imports of major agricultural products amid rising geopolitical risks.

● Remedy deficiencies in end-stage supply for rural areas and vulnerable groups, and standardize the market order of online platforms. Incorporate the development of last-mile logistics in underdeveloped regions into long-term infrastructure planning to narrow the urban-rural delivery gap. Targeted food security mechanisms shall be established for low-income groups. Supervision over algorithm-based pricing and market monopolies of platforms needs to be tightened, so as to prevent the expansion of digital retail from exacerbating difficulties in food access among vulnerable populations.

The resilience building of agrifood systems relies not only on stable supply at the production end, but also on the effective operation of intermediate links connecting production and consumption. Encompassing warehousing and logistics, food processing, international trade and retail distribution, these links form the core supporting network that delivers food from farms to tables.

## 3.1 The Importance of Resilience in Intermediate Links of Agrifood Systems

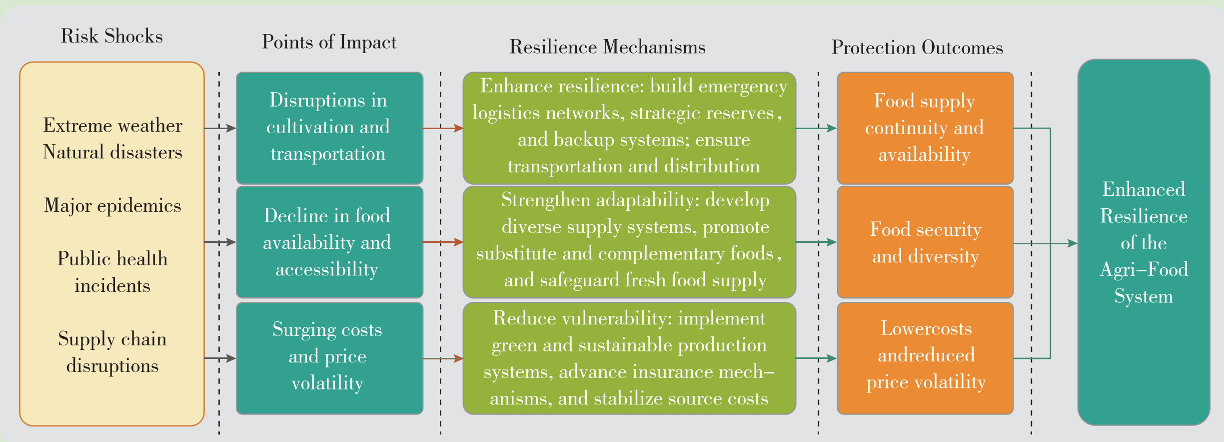
Under normal conditions, intermediate links perform basic functions including reducing post-harvest losses, stabilizing prices and improving food accessibility. In the face of external shocks, their strategic value becomes even more prominent. The redundancy and stress resistance of these links not only determine whether the agrifood system can maintain adequate supply, but also act as core variables affecting food availability, nutrition security and price stability. Accordingly, to guarantee safe and stable food supply for end consumers, it is imperative to strengthen supply chain resilience. While improving food distribution efficiency, the buffering and regulating functions of intermediate links should be fully leveraged to ensure timely and steady food delivery to consumers.

### 3.1.1 Warehousing and Logistics: The Structural Foundation of Agrifood System Resilience

As core infrastructure, a sound warehousing and logistics system mitigates seasonal fluctuations in food output and prices through temporal and spatial regulation. They also serve as a strategic buffer amid shocks, sustaining the continuity and stability of food supply chains. Specifically, they contribute to agrifood system resilience through three major pathways (Figure 3-1).

First, emergency logistics distribution capacity safeguards food accessibility during crises. Extreme weather events and public health emergencies often disrupt or paralyze transportation infrastructure, severely hindering the delivery of food from production areas and reserve depots to affected populations. Therefore, the capacity of warehousing and logistics systems to operate amid infrastructure damage, including activation of alternative road networks, deployment of emergency distribution nodes and reserve allocation mechanisms, is critical to ensuring food accessibility under shocks. China's well-established network of emergency food supply infrastructure and logistics systems has laid a solid foundation for food resilience at the consumption end. During the COVID-19 pandemic, many cities imposed traffic control and community lockdowns. Relying on the national emergency food security system, green transport corridors and last-mile community delivery networks, China rapidly resumed the supply of grain, edible oil, vegetables and other daily necessities, effectively mitigating local food shortages and supply disruptions. By the end of 2022, China had 4,846 emergency storage and transportation enterprises, 3,542 emergency distribution centers and 56,495 emergency supply outlets (State Administration of Grain and Reserves,

**Figure 3-1** Guarantee mechanisms of supply chain for the resilience of agrifood systems

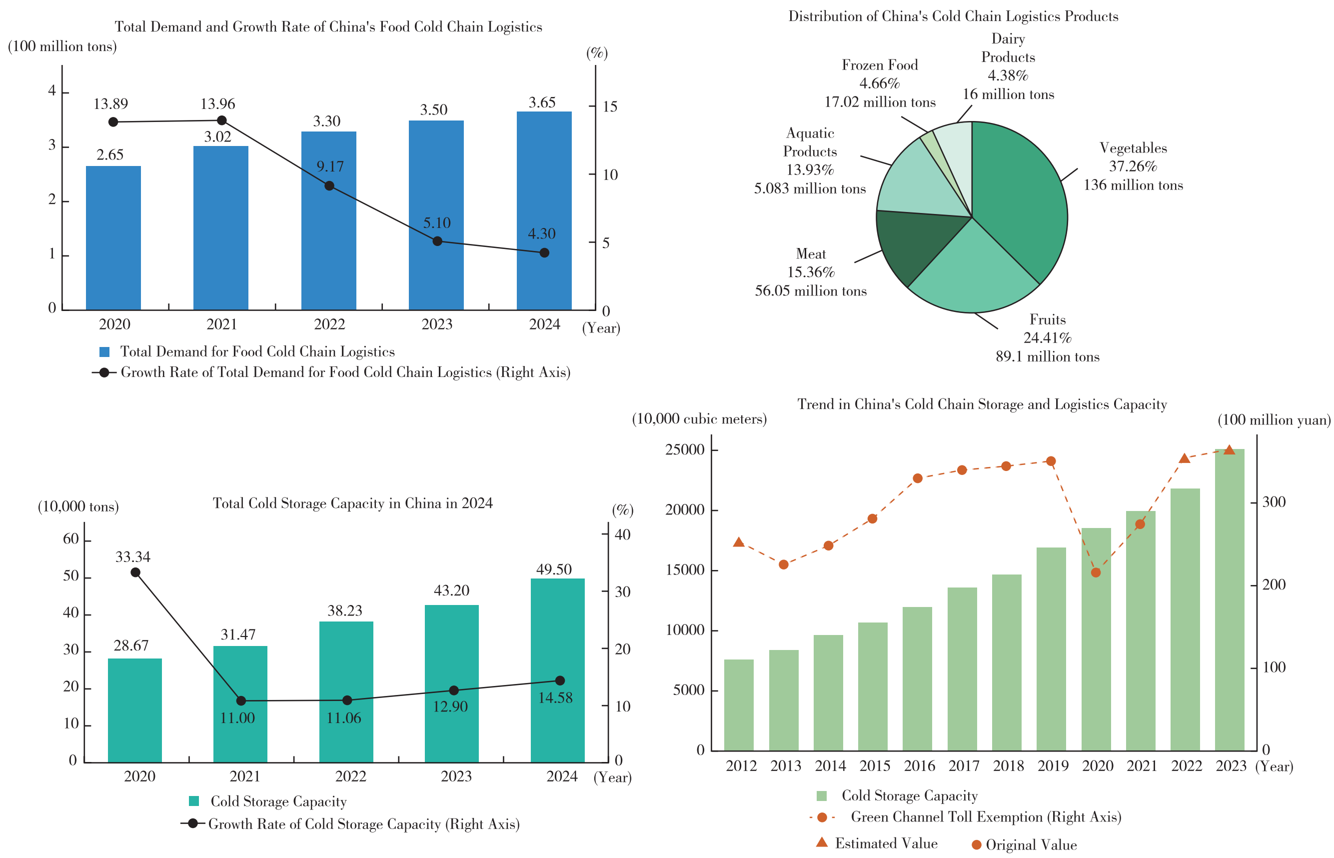



**Source:** Compiled by the authors.

2025). During the 14th Five-Year Plan period, the reserve volume of finished grain and oil in 36 large and medium-sized cities could meet market demand for more than 15 consecutive days. The usable capacity of standard grain warehouses nationwide exceeded 700 million tons, the capacity of low-temperature and quasi-low-temperature warehouses surpassed 200 million tons, and the capacity of warehouses adopting controlled atmosphere storage technology exceeded 55 million tons. These figures demonstrate that the current system possesses basic buffering capacity to cope with short-term supply shocks (The State Council Information Office, 2025; Guangming Network, 2023).

Second, cold chain logistics capacity underpins the stable supply of nutritious and perishable food under shocks. The policy objectives of agrifood system resilience have evolved from simply securing calorie supply to safeguarding nutrition well-being, namely maintaining the continuous supply of diversified foods such as meat, eggs, aquatic products, fresh fruits and vegetables during crises. Modern cold chain technologies help preserve the freshness, safety and nutrient content of perishable food throughout circulation. In 2024, the total volume of on-farm storage and preservation facilities reached 307.427 million cubic meters, with a holding capacity of 66.945 million tons. Statistics for 2023 show that 32% of fresh agricultural products underwent pre-cooling and refrigeration treatment at production sites (Ministry of Agriculture and Rural Affairs, 2025). In terms of transport capacity, the number of refrigerated trucks nationwide reached 495,000 by 2024, representing a roughly 73% increase since 2020. The continuous expansion of transport capacity provides robust hardware support for the stable circulation of fresh agricultural products (China Federation of Logistics & Purchasing Cold Chain

**Figure 3-2 Status of China's Food Cold Chain Logistics System (2020-2024)**




**Note:** Missing values for green-channel toll exemptions were estimated using trend extrapolation. The anomalous value for 2020, attributable to the COVID-19 pandemic, was excluded from the model fitting. The linear trend forecast was based solely on data from 2013-2019 and 2021. Triangles indicate estimated values, while circles indicate original observations.

**Data sources:** China Federation of Logistics and Purchasing Cold Chain Logistics Committee (2025) and the National Bureau of Statistics of China.

Committee, 2025).

Third, institutional mechanisms that reduce logistic fee maintain the system efficiency amid shocks. Logistics costs constitute a major structural bottleneck for emergency responses. Under normal operations, high logistics costs limit the effective circulation radius of perishable products. In emergency situations, unregulated surges in freight rates will further hinder inter-regional food allocation and exacerbate local supply shortages. The Chinese government has implemented a green channel policy for the transportation of fresh agricultural products, granting full exemption from expressway tolls for fully loaded vehicles carrying such goods. Annual toll exemptions exceed CNY30 billion (Ministry of Transport, 2023). By systematically cutting transport costs, this policy greatly expands the geographic coverage of emergency supply efforts and provides strong institutional guarantees for the sustained operation of warehousing and logistics systems amid external shocks.

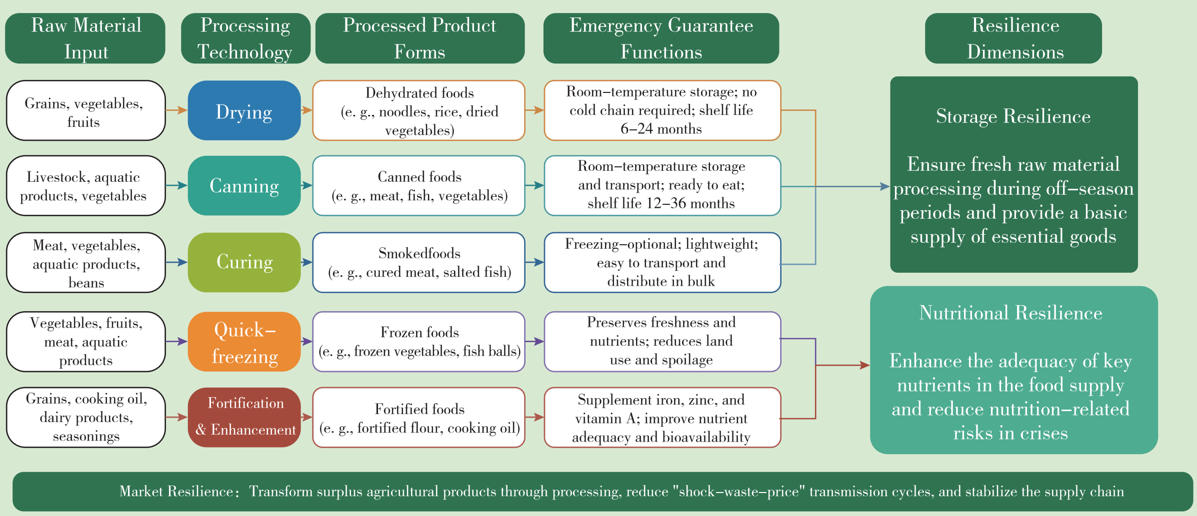
### 3.1.2 Food Processing: A Functional Guarantee for Agrifood System Resilience

Through technologies such as drying, pickling, canning, quick freezing and nutrition fortification, the food processing industry converts perishable raw agricultural products into processed foods featuring durable, transportable and nutritionally controllable. It systematically reduces the reliance of the entire food chain on stringent storage and transportation conditions, and structurally improves the fault tolerance of agrifood systems against external shocks. China's food processing sector includes agricultural and sideline food processing and food manufacturing, with its total output value exceeding CNY10 trillion (Xu Kunlin, 2025). It serves as a fundamental industrial pillar underpinning the operation of agrifood systems. The industry contributes to the guarantee capacity of agrifood systems mainly through three pathways (Figure 3-3).

First, capacity for emergency food supply. When hit by extreme weather, major epidemics, natural disasters and other shocks, fresh food supply chains are the first to fail. Interrupted cold chains, blocked transportation routes and abnormal storage temperatures may cause massive losses of fresh agricultural products in a short period, leaving affected populations short of food. Thanks to extended shelf life, portability and ready-to-eat attributes, processed foods act as the most practical alternative when fresh food supply fails. By the end of 2022, China had 6,584 grain emergency processing enterprises, which can swiftly launch alternative supply when regular channels break down and provide sufficient production capacity for emergency support (State Administration of Grain and Reserves, 2025).

Second, capacity for nutrition fortification and supplementation. During crises, people face drastically constrained food choices, and diversified supplies of fruits, vegetables, meat, eggs and dairy products are often inaccessible, leading to a notably higher risk of

**Figure 3-3 Guarantee Mechanisms of the Food Processing Industry for Resilience of Agrifood Systems**




**Source:** Compiled by the authors.

micronutrient deficiencies, especially among vulnerable groups including children, pregnant women and the elderly. With nutrition fortification technologies, the food processing industry enriches staple processed foods such as fortified flour, edible oil and soy sauce with essential micronutrients including iron, zinc, vitamin A and folic acid. In times of food scarcity, these products maintain residents' basic nutrition status in a cost-effective and widely accessible manner, forming a resilient bottom line for food and nutrition security amid shocks.

Third, capacity for food loss reduction and price stabilization. When supply chains come under strain and circulation is disrupted, highly perishable fresh produce tends to spoil rapidly due to delayed sales and delivery, resulting in soaring food losses and shrinking effective supply. Meanwhile, reduced supply drives sharp price hikes, which further undermines food access for farmers and low-income groups and creates a vicious cycle of shock to food loss to price surge, and to deteriorated accessibility. By processing surplus or damaged agricultural products unsuitable for fresh sales into long-shelf-life goods at production sites or in circulation links, the food processing industry stabilizes total effective market supply and curbs supply contraction caused by spoilage. Furthermore, it absorbs excess produce amid shocks to lower food acquisition costs and prevent price hikes from triggering food and nutrition security crises among low-income communities.

### 3.1.3 International Trade: An External Buffer for Agrifood System Resilience

International trade offsets domestic production shortfalls, smooths price fluctuations and diversifies concentrated supply chain risks through cross-border food flows. Its resilience value lies primarily in its external function: when domestic systems are hit by shocks, supplies from global markets can maintain basic food stability without fully relying on the recovery of domestic production capacity. As the world's second-largest importer of agricultural products, China recorded agricultural imports worth USD207.4 billion in 2025. Major imported commodities include soybeans, meat, dairy products, fresh and dried fruits, and wine. These imports effectively bridge structural supply-demand gaps in the domestic market, diversify food choices for consumers, and create vast market opportunities for global agricultural producers.

First, food imports expand the emergency supply network during crises. When domestic food production is disrupted by extreme weather, major epidemics or regional supply chain breakdowns, the rapid mobilization of overseas supply channels serves as a critical emergency mechanism to stabilize agrifood systems. Its effectiveness hinges on the coverage and diversification of existing import networks. China has established agricultural trade ties with 165 countries and regions worldwide, covering a full range of products such as grains, meat, aquatic products, fruits, vegetables and dairy goods, thereby forming an extensive import supply network. In the event of temporary domestic food shortages, China can mobilize supplementary imports from multiple continents and countries simultaneously, preventing emergency failures caused by over-reliance on any single supply source.

Second, international trade leverages comparative advantages and regulates dietary costs. A core objective of agrifood system resilience is to ensure residents have access to diversified and nutritionally adequate food at affordable prices. Guided by the principle of comparative advantage, international trade enables large-scale procurement of specific food products from regions with the highest production efficiency worldwide, systematically lowering domestic food acquisition costs. This plays a particularly vital role in strengthening the resilience of nutrition security. Some nutrient-dense foods, such as soybean protein, dairy products and edible oil, would incur far higher production costs if sourced entirely domestically, making diversified nutrition intake unaffordable for low-income groups. Trade facilitates the stable supply of such foods at lower prices, structurally expanding effective nutrition accessibility for residents across all income brackets. Taking dairy products as an example, China imports approximately 1.4 million tons of milk powder annually, mainly from New Zealand, the European Union and other regions abundant in grassland resources with substantially lower production costs. Large-scale imports have kept domestic dairy prices in check, enabling urban and rural residents to obtain high-quality protein and calcium at a reasonable cost on a daily basis.

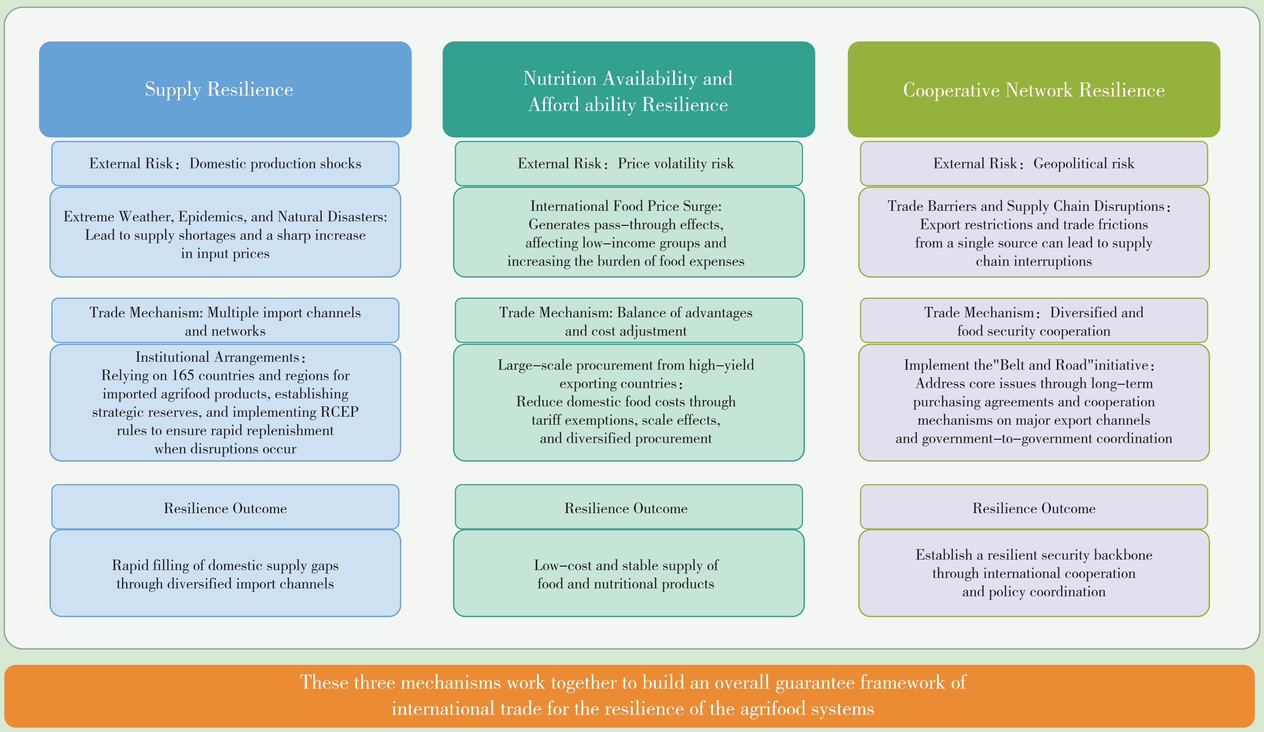
Third, bilateral and multilateral food security cooperation builds collaborative networks to address shocks. Global food trade is deeply embedded in geopolitical dynamics, and market mechanisms face prominent limitations amid rising geopolitical risks. Bilateral food security agreements, including long-term procurement deals, agricultural investment cooperation and reciprocal food aid arrangements, establish contractual supply guarantees between sovereign states, acting as institutional anchors that stabilize import channels beyond market operations. China has prioritized food security cooperation under the Belt and Road Initiative. It has signed long-term agricultural cooperation agreements with major agricultural exporters including Brazil, Russia and Kazakhstan, and expanded overseas food production capacity through outbound agricultural investment.

### 3.1.4 End Retail: The Last-Mile Guarantee for Agrifood System Resilience

The retail sector serves as the last mile connecting agrifood systems to end consumers, directly governing the accessibility, stability and safety of food access for residents. In recent years, China's food retail landscape has gradually evolved from a traditional model dominated by brick-and-mortar outlets into an online-offline integrated system centered on digital platforms, delivering marked improvements in responsiveness and operational efficiency of end supply. According to the 2023 China Online Retail Market Development Report, online retail sales of agricultural products nationwide reached 587.03 billion yuan in 2023, representing a year-on-year growth of 12.5%. Sales of key monitored online catering platforms rose by 29.1%, among which takeaway revenue accounted for 78.4% with a year-on-year increase of 18.3% (China International Electronic Commerce Center, Ministry of Commerce, 2024). The number of food delivery riders across the country has exceeded ten million and continues to grow rapidly (Xinhua News Agency, 2025). The instant delivery system, with digital platforms as scheduling hubs and rider networks as final distribution terminals, has greatly accelerated food supply response and expanded spatial coverage, strengthening the adjustment capacity of urban agrifood systems against short-term shocks. End retail underpins agrifood security through three major mechanisms:

First, extensive last-mile network coverage ensures

**Figure 3-4 Guarantee Mechanism of International Trade for Resilience of the Agrifood Systems**



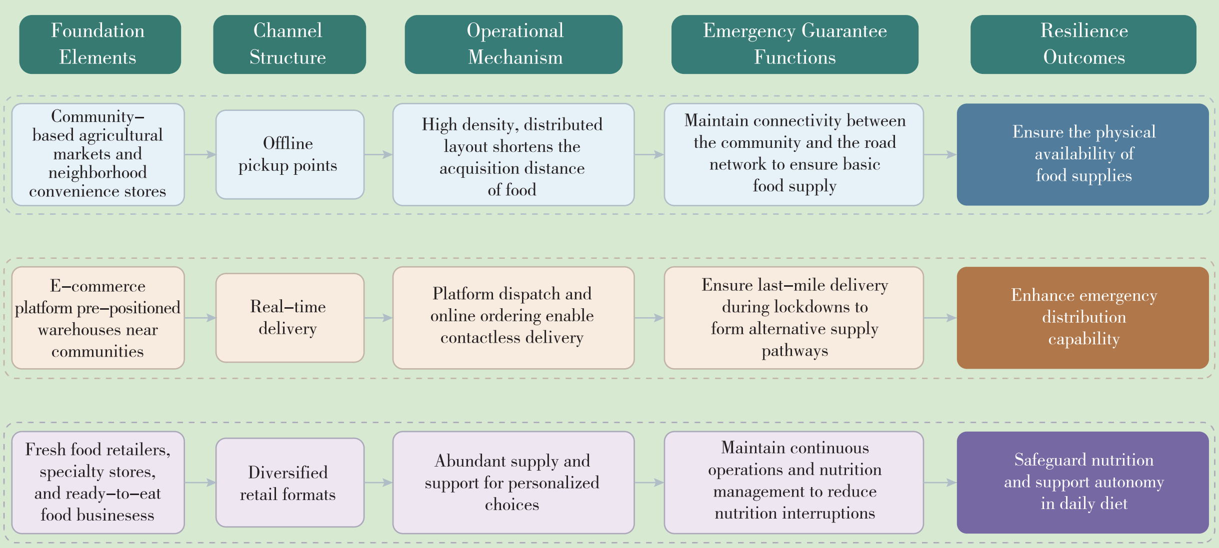

**Source:** Compiled by the authors.

physical food accessibility during crises. The density of retail outlets determines whether residents can obtain food nearby when transportation and mobility are restricted. A denser retail network means more walkable food sources and mitigates the impact of individual outlet closures on local supply. China boasts over 40,000 farmers' markets nationwide. Together with chain supermarkets and community convenience stores, they form a high-density end retail network that substantially shortens the travel radius for food procurement in both urban and rural areas. Thanks to their decentralized and localized features, farmers' markets can maintain basic food supply for local communities when large supermarkets are disrupted, demonstrating the resilience advantages of small-scale, distributed retail nodes under extreme conditions.

Second, digital retail and instant delivery enhance emergency distribution channels. Lockdown measures during the COVID-19 pandemic in 2020 fully revealed the strategic value of digital retail. When physical retail premises were shut down due to control policies, e-commerce platforms and instant delivery services became the primary alternative for urban residents to access food. Digital retail platforms represented by JD.com, Meituan and Dingdong Maicai rely on reserve warehouses, front warehouses and rider delivery networks to ensure food reaches households during lockdowns, effectively filling supply gaps left by suspended traditional retail. A core strength of this model is its low reliance on physical venues: as long as delivery personnel can operate, digital retail can function continuously even when offline retail is paralyzed. Currently, the scale of China's instant retail market has surpassed CNY600 billion. The expanding network of front warehouses covering urban communities provides increasingly robust infrastructure for last-mile food distribution in emergencies.

Third, diversified food offerings support independent nutrition choices amid shocks. Materials distributed via government emergency supply schemes prioritize calorie provision with relatively limited product varieties. By contrast, end retail enables residents to make independent choices in accordance with personal nutrition needs, which is particularly critical amid prolonged crises. By offering a diverse range of products including fresh produce, dairy items, special dietary foods, and low-sugar and low-salt alternatives, retail channels allow people to sustain personalized nutrition management during emergencies. During the COVID-19 outbreak, online searches and purchases of foods for special medical purposes, infant formula and therapeutic diets for chronic diseases surged on e-commerce platforms, reflecting strong public demand for independent nutrition selection in crisis situations. This indicates that end retail contributes to agrifood system resilience not merely by ensuring food availability, but also by enabling access to food that meets individual health-specific needs.

**Figure 3-5 Guarantee Mechanisms of the Retail Sector for Agrifood System Resilience**




**Source:** Compiled by the authors.

## 3.2 Risks and Challenges Facing Intermediate Links of Agrifood Systems

As external risks and uncertainties intensify, intermediate links have borne the brunt of pressures. Figure 3-6 illustrates multiple risks and their impacts on different segments.

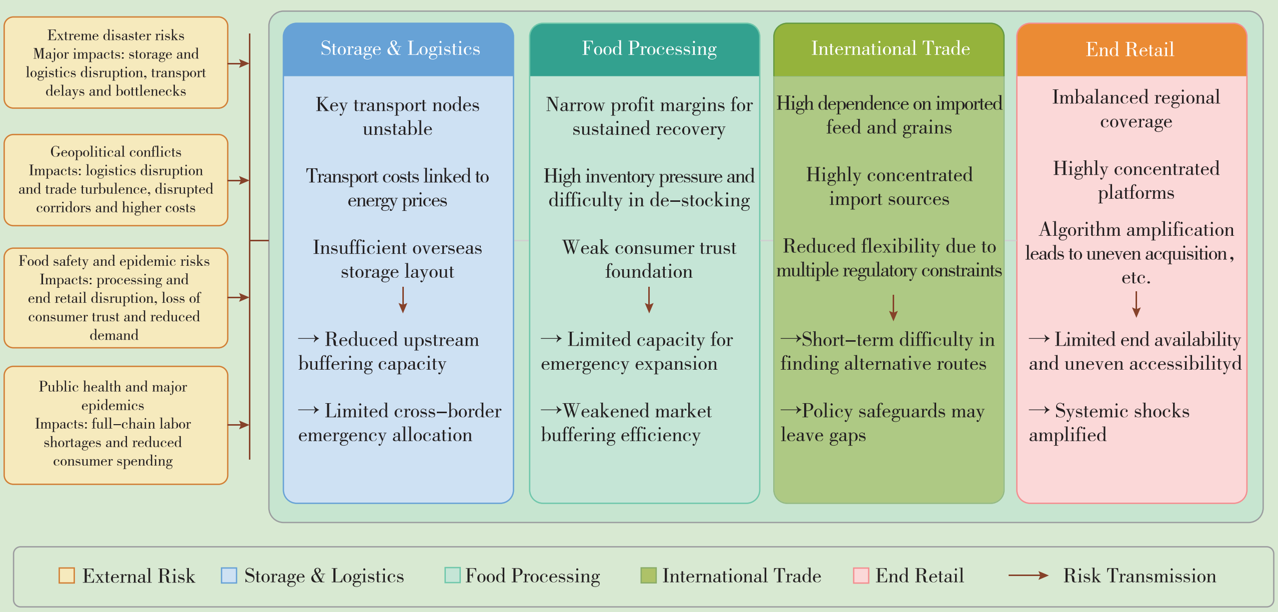
*Extreme disaster risks*. Warehousing and logistics are highly vulnerable to extreme disasters. Severe weather such as heavy rain, floods and extreme cold may cut off transport routes, damage storage facilities and cause delivery delays, posing serious threats to the preservation and circulation of fresh agricultural products. In 2025, China recorded the longest heatwave in history. North China experienced an unusually prolonged rainy season, and severe floods swept across many northern regions. These disruptions severely hindered the transportation and distribution of grain and fresh produce, driving up warehousing and logistics costs substantially.

*Geopolitical conflicts.* Such risks disrupt shipping lanes and trade rules for major global agricultural commodities and production inputs, push up import prices and prolong the turnover cycle of cross-border trade, thereby increasing the fragility of the global food trade system. For instance, since the outbreak of the US-Israel-Iran conflict in March 2026, the sharp surge in transport costs has greatly reduced the economic viability of emergency allocation. Logistics expenses have become a major bottleneck constraining emergency responses (Box 3-1).

*Food safety and public opinion risks.* These risks mainly affect food manufacturing, catering and retail sectors. As public awareness of food safety increases, related incidents will erode consumer confidence, triggering cascading market fallout including plummeting demand, overstocked inventory and business closures. The public debate surrounding pre-prepared Xibei Catering in 2025 exposed the structural friction between the expansion of industrialized food production efficiency and consumer trust. Once public confidence is undermined, the social acceptance of processed foods during emergencies will decline markedly. This weakens their practical value as alternative emergency supplies and impairs the overall role of the food processing industry in building agrifood system resilience.

*Zoonoses and major epidemics.* These risks feature prominent cross-regional, cross-species and cross-sectoral impacts. They not only disrupt production stability directly, but also trigger systemic disturbances across intermediate links via labor shortages, suspended processing, restricted logistics and weakened consumer confidence. For example, prolonged quarantine

**Figure 3-6 Risk Transmission Framework of the Food Supply Chain under Various Risk Scenarios**




**Source:** Compiled by the authors.

**Box 3.1** Disruptions to the Strait of Hormuz and Impacts on the Global Agrifood System

Escalating conflicts in the Middle East in early 2026 drastically reduced shipping capacity across the Strait of Hormuz. As a critical hub for trade in energy, fertilizers and agricultural products, disruptions to the strait have driven up transportation and production costs and undermined the stability of global agrifood systems through multiple channels.

Maritime freight costs and uncertainties surrounding cross-border logistics have increased markedly. Disruptions in the Strait of Hormuz first disturbed shipping operations and pushed up logistics expenses. In March 2026, the average daily number of vessels passing through the strait plummeted from around 130 in February to merely 6, representing a decline of approximately 95%. War risk insurance premiums soared from 0.25% of vessel value to a maximum of 10%, with premiums reset on a weekly basis. Consequently, costs related to port turnover, in-transit inventory, insurance and warehousing rose simultaneously. Logistics chains for agricultural products, fertilizers and animal feed were extended considerably, leading to a notable deterioration in supply chain stability.

Second, rising fertilizer prices risk missing critical farming windows. The strait handles around 20 million barrels of crude oil per day, nearly one-fifth of the world's liquefied natural gas, and up to 30% of global fertilizer trade. The Gulf region also accounts for roughly half of the world's sulfur trade. Shipping disruptions have simultaneously increased fuel costs and disrupted the supply of nitrogen and phosphate fertilizers. In the first week of March, the price of granular urea from the Middle East rose by 19%, while urea prices in Egypt surged by 28%. Persistent delays in transportation and distribution will translate into postponed fertilization schedules, which will in turn adversely affect crop yields.

Third, elevated oil prices amplify the substitution effect of biofuels and pose threats to global food security. If disruptions last for more than three months, high oil prices will boost the economic competitiveness of ethanol and biodiesel, driving up demand for agricultural commodities such as corn and soybean oil used as energy feedstocks. When international crude oil prices stand above 80–100 US dollars per barrel, biofuel production will compete with food and feed consumption for agricultural products. This will reduce the volume of tradable grain and further exacerbate price volatility.

Data Sources: Reports of the United Nations Conference on Trade and Development (UNCTAD), expert briefings by the Food and Agriculture Organization of the United Nations (FAO), and relevant media compilations (March 2026).

procedures and stricter inter-provincial transportation limits have lowered the turnover efficiency of live pigs and pork products in processing and circulation, further amplifying the disruption of epidemics on end-market supply.

The above risks represent external pressures on the system. Nevertheless, whether intermediate links can deliver resilient performance amid shocks also depends on their inherent structural conditions. In fact, the four segments — warehousing and logistics, food processing, international trade and end retail — have accumulated distinct endogenous vulnerabilities in daily operations. These vulnerabilities may remain inconspicuous under normal circumstances, yet they will greatly raise the risk of systemic instability when compounded with external shocks.

### 3.2.1 Warehousing and Logistics

First, instability at key shipping nodes undermines the reliability of cross-border grain logistics. Global trade and imports rely heavily on a few critical chokepoints, including the Strait of Malacca, Panama Canal, Suez Canal–Bab-el-Mandeb, and Strait of Hormuz. In 2022, the Panama Canal recorded 14,239 vessel transits; the Suez Canal saw over 24,000 transits, handling approximately 10% of global seaborne trade volume. Roughly 60% of China's merchant ships pass through the Strait of Malacca each year (Research Center for Xi Jinping's Economic Thought, 2024). In recent years, conflicts such as the US–Israel–Iran confrontation, the Red Sea crisis, and disputes over Panama Canal access have significantly destabilized these routes, exposing agricultural shipping to potential rerouting risks.

Second, energy price volatility drives transport costs, weakening the logistics system's emergency response capacity. The resilience of warehousing and logistics depends not only on route availability but also on cost controllability. China's agricultural import transport costs are highly correlated with international oil prices and insurance premiums. Since the outbreak of the US–Israel–Iran conflict in March 2026, crude oil prices have exhibited sharp, shock-driven fluctuations. The resulting surge in transport costs has directly reduced the economic viability of emergency allocations—precisely when expanded imports are most needed to bridge domestic supply gaps, logistics expenses become a critical bottleneck for emergency responses.

Third, inadequate overseas warehousing limits front-end buffering and emergency deployment capabilities. Autonomous control over overseas storage and transshipment facilities in major grain-producing regions and key shipping nodes is foundational to logistics emergency response. However, China's overseas warehousing footprint in these strategic locations remains limited, with only moderate control over port grain terminals and supporting logistics infrastructure, which are largely operated by external entities. This gap means that when cross-border transport faces disruption risks, there is insufficient "front-end buffer" to buy response time, significantly diminishing the logistics system's cross-border emergency deployment function.

### 3.2.2 Food Processing

First, narrowing profit margins constrain the sustainability of emergency supply capacity. A core value of the food processing industry in resilience building is its ability to rapidly scale production and substitute fresh food during shocks. However, total profits of the agricultural and sideline food processing industry have declined steadily since a peak in 2016, while growth in the food manufacturing industry has stagnated. Compressed profit margins directly reduce enterprises' willingness and ability to maintain emergency production capacity reserves, invest in technological upgrades, and upgrade infrastructure. When external shocks occur, financially strained firms often struggle to quickly scale output or adjust production models, limiting the industry's emergency supply function when it is most needed.

Second, high inventory levels weaken the buffer effect of market adjustment. Another critical contribution of food processing to agrifood system resilience is absorbing surplus agricultural products and stabilizing prices through processing. However, aggregate inventory in the food industry has risen over the past decade. Inventories in the agricultural and sideline food processing industry increased from approximately CNY320 billion in 2012 to nearly CNY680 billion in 2025, while food manufacturing inventories grew from CNY100 billion to over CNY260 billion. High inventory, combined with rising asset-liability ratios, makes enterprises slower and more conservative in responding to market signals. This means firms lack incentives to expand procurement and processing during supply gluts, and face funding constraints limiting rapid allocation during demand spikes—undermining their role as a price and supply buffer for the agrifood system.

Third, food safety public opinion risks erode the foundation of resilience. The food processing industry's role in resilience building depends not only on production and logistics capacity but also on consumer trust in processed foods. As public awareness of food safety grows, industry sensitivity to public opinion risks has increased. The rapid escalation of the Xibei pre-made dishes controversy in 2025 starkly revealed the structural tension between industrialized food production efficiency and consumer trust. Once trust is damaged, public acceptance of processed foods during emergencies declines sharply, reducing their practical value as emergency supply alternatives and impairing the industry's overall function in agrifood systems resilience.

### 3.2.3 International Trade

First, the heavy reliance on imported feed grains and high price sensitivity undermine the long-term stability of supply. Imports of wheat and rice have long accounted for a small share of domestic output, so staple food sectors are mainly exposed to marginal external shocks. In contrast, China's reliance on imported soybeans remains extremely high, with import volumes several times its domestic production in recent years. Fluctuations in global markets, trade frictions and shipping risks can be directly transmitted to the domestic supply system. Historically, major events including the COVID-19 pandemic in 2020, the Russia-Ukraine conflict in 2022, as well as the launch and suspension of the Black Sea Grain Initiative all triggered pronounced swings in import prices. This indicates that the import costs of key agricultural commodities are highly vulnerable to geopolitical tensions and logistics disruptions worldwide.

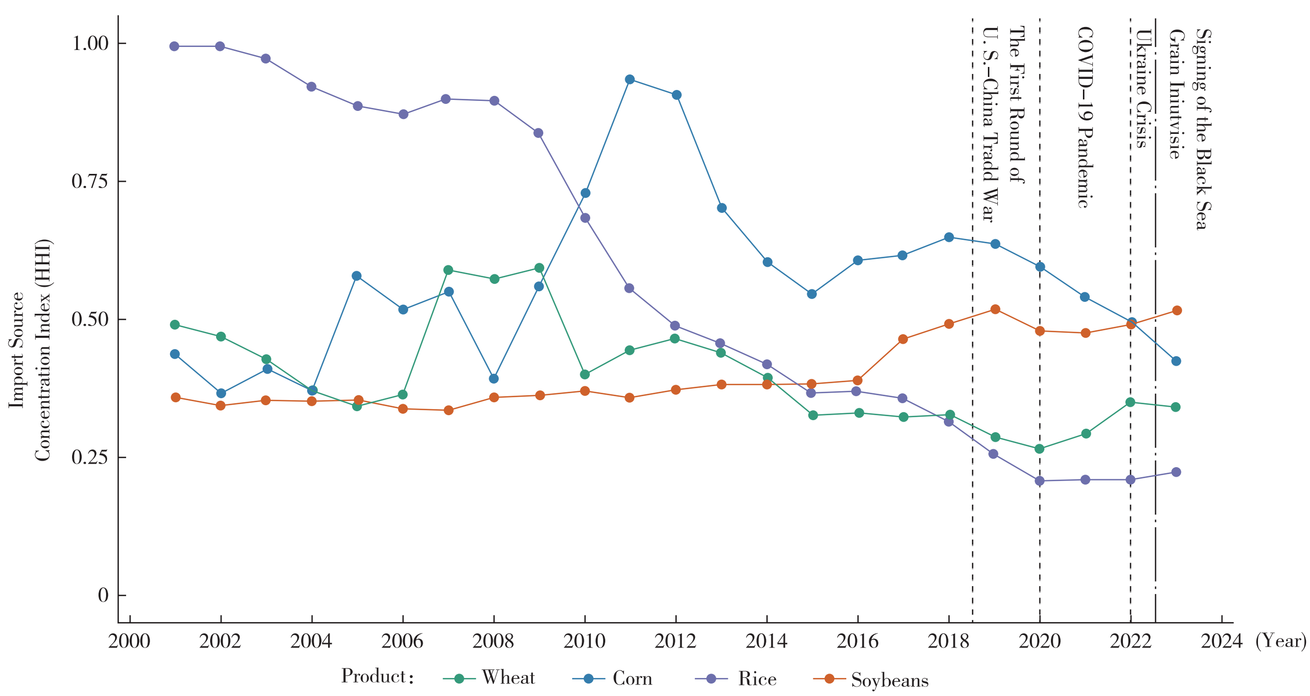
Second, imports of major commodities are overly concentrated in a handful of sources, making it difficult to disperse regional risks. Diversified import channels build redundancy against supply disruptions and underpin resilience. Nevertheless, China's import sources for critical agricultural products remain highly concentrated: 97% of soybean imports come from Brazil, the United States and Argentina; 93% of corn imports are sourced from Brazil, the United States and Ukraine; and 81% of wheat imports rely on Australia and Canada. Calculations based on the Herfindahl-Hirschman Index (HHI) reveal persistently high concentration in soybean imports, which reached 0.552 in 2024. In this context, extreme weather, policy adjustments or deteriorating bilateral relations in major supplier countries will leave few alternative import channels to fill supply gaps in the short run, greatly impairing the emergency supply resilience of the diversified supply network (Figure 3-7).

Third, declining enforceability of multilateral trade rules creates systemic gaps in institutional supply guarantees. Bilateral and multilateral trade mechanisms provide institutional stability beyond market transactions for cross-border food supply, serving as a vital pillar for agrifood system resilience. However, the suspension of the WTO Appellate Body since 2017 has essentially paralyzed the multilateral dispute settlement mechanism and substantially weakened the effectiveness of institutional safeguards. As an alternative approach, China has actively advanced regional and bilateral trade agreements. From January to April 2025, China's agricultural trade with RCEP member states reached USD31.93 billion, accounting for 34.4% of the country's total agricultural trade in the same period, which demonstrates the stabilizing role of regional agreements. Even so, RCEP contains numerous flexible clauses regarding agricultural market access, mutual recognition of inspection and quarantine standards and dispute settlement, resulting in limited binding force. Most trade relations still depend on case-by-case diplomatic consultations and temporary quota arrangements. When confronted with sudden trade restrictions or geopolitical frictions, the existing institutional framework fails to effectively secure stable imports of key agricultural products.

### 3.2.4 End Retail

First, unbalanced regional coverage hinders equitable food accessibility. While instant delivery systems are well-developed in first-tier cities, cold chain facilities and distribution networks remain inadequate

**Figure 3-7** Trend in Import Source Concentration for China's Major Agrifood Products (3-Year Moving Average)




**Note:** Import source concentration is measured using the Herfindahl-Hirschman Index (HHI).

**Source:** UN Comtrade; the HHI values were calculated and compiled by the authors.

in central and western regions as well as rural areas. According to data from the China Federation of Logistics & Purchasing, the coverage rate of rural courier outlets stood at only 78% in 2024, far below the 98% recorded in urban areas. In addition, rural logistics costs are over 30% higher than those in cities. Under extreme weather or traffic disruptions, the last-mile delivery network is prone to temporary failures and elevated risks of local supply disruptions (Jiang Hui, 2025). Consequently, resilience safeguards are the weakest precisely in regions and groups most in need of support.

Second, high market concentration among platforms amplifies the transmission risks of systemic shocks. The fresh e-commerce and community group-buying sectors are currently highly concentrated, with leading platforms dominating supply organization and price formation. According to estimates by Guosen Securities, the top three instant retail platforms, such as Meituan Flash Purchase, JD.com and Taobao Instant Delivery, jointly hold approximately 60% of the market share (Guosen Securities, 2025). Against this backdrop, operational turbulence, technical malfunctions or liquidity strains at major platforms can trigger shocks that spread rapidly across supply chains and destabilize agrifood systems. China now has more than ten million food delivery riders nationwide, the majority of whom work for Meituan and Taobao Instant Delivery. Delivery capacity can be severely constrained by pandemics, extreme weather or abnormal algorithmic scheduling, which may lead to regional or temporary food supply shortages or delays and heighten instability on the consumption side.

Third, algorithm-based distribution exacerbates food access inequality across social groups. Algorithmic pricing and personalized recommendation systems widely adopted by online platforms have widened disparities in pricing and information access among users. Practices such as big data-enabled price discrimination against existing customers pose major regulatory challenges. Low-income groups and people with limited digital literacy often face higher actual costs for food access. Although the expansion of end retail has improved overall supply efficiency, such institutional biases have created new barriers to accessibility for vulnerable groups, who rely most on resilience safeguards.

Fourth, cyber risks and platform integrity issues undermine the stability of digital supply systems. Digital end retail faces multiple threats including cyberattacks, system outages, payment failures, communication breakdowns and data leaks. Meanwhile, problematic order management within platforms also merits attention. The improper reallocation of so-called ghost food delivery orders indicates that order data can be tampered with or concealed by intermediate operators, creating a major information gap where the actual sources of food deviate drastically from the information displayed on platforms. The combination of these risks may seriously compromise the reliability and traceability of end food supply under extreme scenarios.

## 3.3 Construction and Capacity Evaluation of Resilience Monitoring Indicators for Intermediate Links of Agrifood Systems

### 3.3.1 Resilience Indicator System

Based on the analysis of characteristics of key intermediate links including food processing, warehousing and logistics, international trade and end retail, this report further constructs a monitoring indicator system for the resilience of agrifood supply chains (see Appendix). Different from traditional evaluation methods focusing on scale or efficiency, this report is guided by dynamic resilience and systematically restructures indicators from three dimensions namely resistance capacity, recovery capacity and transformation capacity. It should be noted that existing statistical data mainly reflect the operational status of the system and cannot directly measure resilience. Therefore, this report adopts the approach of proxy variables plus derived indicators to convert original statistical indicators into functional indicators that reflect the dynamic response capacity of the system. Specifically, volatility indicators are constructed to describe system stability, change rate indicators to reflect recovery capacity, and structural indicators to represent adaptability, thereby realizing the transformation from static description to dynamic resilience measurement.

First, resistance capacity. Resistance capacity refers to the ability of a system to maintain basic operational stability when external shocks occur, and its core lies in buffer space and fluctuation control. This report mainly describes it from two aspects including reserve capacity and shock fluctuation. On the one hand, the inventory scale of food processing industry and cold storage capacity are selected as basic buffer capacity indicators to reflect the physical reserve capacity of the system in the event of supply disruptions or demand fluctuations. On the other hand, volatility indicators are further constructed on this basis, including the price volatility index calculated based on import prices of agricultural products and the shipping volatility index calculated based on Baltic Dry Index BDI, which are used to characterize the transmission intensity of external shocks in trade and logistics links. A smaller fluctuation range indicates stronger resistance capacity of the system against shocks. In addition, to address the problem that simple inventory scale cannot reflect the actual buffer capacity, this report further establishes the inventory buffer ratio inventory divided by profit to comprehensively measure the relationship between inventory and corporate operational capacity, so as to more accurately reflect the shock resistance of the processing link. Moreover, the volatility indicator of global crude oil prices is introduced as a proxy variable for exogenous shocks to characterize the transmission intensity of energy price shocks to grain trade and logistics systems. Greater oil price volatility means stronger external shocks and higher difficulty for the system to maintain stable operation, which in turn puts pressure on the resistance capacity of food supply chains.

Second, recovery capacity. Recovery capacity refers to the speed at which a system returns to normal operation after shocks, and its key lies in the adjustment efficiency of production and circulation systems. This chapter mainly describes it from two aspects including production recovery and transportation recovery. On the production side, the profit recovery speed indicator is constructed based on profit data of the food processing industry, and the variation range of profit growth rate is used to measure the operational recovery capacity of enterprises after shocks. On the circulation side, the transportation recovery capacity indicator is built based on comprehensive freight volume data to reflect the speed at which the logistics system restores supply capacity after shocks. Meanwhile, the food category of Consumer Price Index CPI is adopted as a key supplementary indicator on the consumption side. CPI not only reflects price levels, but also indicates whether upstream shocks have been transmitted to end consumption. A system with strong recovery capacity can keep end prices relatively stable even if the upstream is impacted. On the contrary, drastic price fluctuations suggest insufficient recovery capacity. Therefore, CPI volatility serves as an important proxy variable for measuring system recovery capacity.

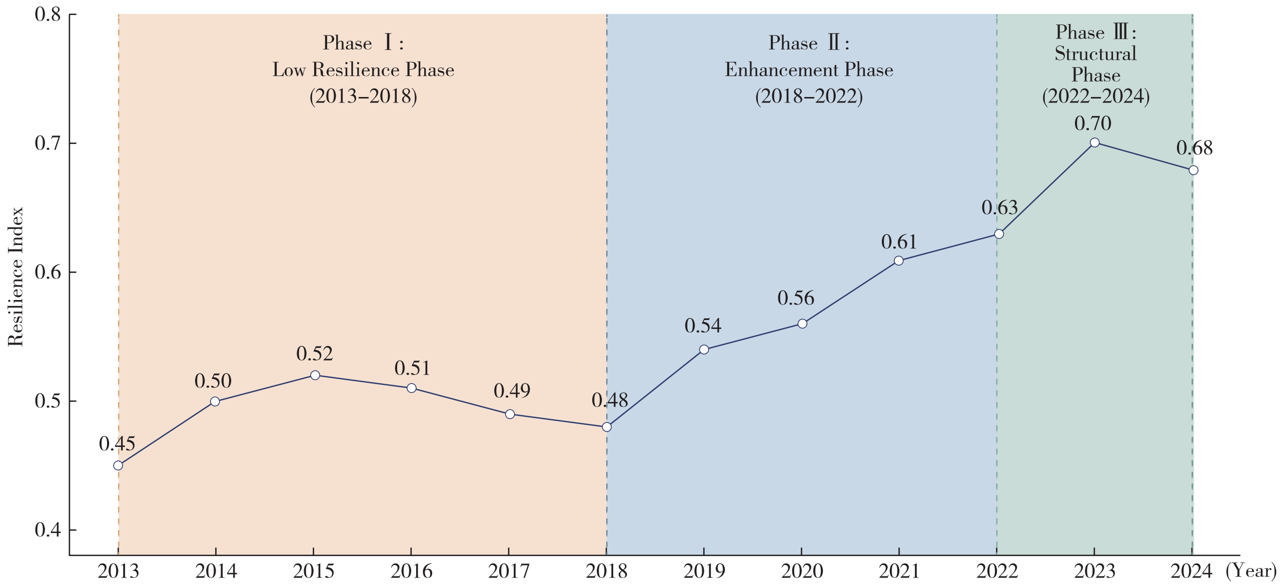
Third, transformation capacity. Adaptability refers to the ability of a system to reduce risks through structural adjustment under long-term uncertain environments, and its core lies in the capacity to adjust external dependence structure and supply source structure. In the trade dimension, agricultural product import dependency and import source concentration Herfindahl–Hirschman Index (HHI) are selected as basic indicators to reflect the degree of the system's reliance on external supplies and the level of risk concentration respectively. On this basis, the risk concentration index import dependency multiplied by concentration is further constructed to depict systemic vulnerability risks under the circumstance of high reliance and high concentration. In addition, the change rate of import dependency is established to characterize the system's capacity to adjust trade structure amid shocks. A higher change rate indicates stronger transformation capacity of the system.

### 3.3.2 Empirical Analysis of Resilience Index Results

According to the calculation results shown in Figure 3-8, the resilience index of intermediate links of agrifood systems presented distinct phased characteristics from 2013 to 2024, which can be divided into three stages.

The first stage is the low-level accumulation period from 2013 to 2018. The index fluctuated at a low level within the range of 0.45 to 0.52, indicating an overall weak resilience. During this period, the intermediate links of China's agrifood systems were still in the stage of basic capacity accumulation. Cold storage capacity was limited, comprehensive freight capacity remained imperfect, and scale effects of food processing enterprises had not yet taken shape. All dimensional indicators stayed at low levels, resulting in insufficient overall resistance

**Figure 3-8** Trend in the Resilience Index of the Intermediate Stages of the Agrifood Systems, 2013–2024




**Source:** Calculated and compiled by the authors.

and recovery capacity of the system. Meanwhile, import sources of international trade channels were highly concentrated in this period. The reliance on a small number of supplier countries for key commodities such as soybeans kept increasing, and the import risk concentration index remained high, which dragged down the overall resilience index to a certain extent.

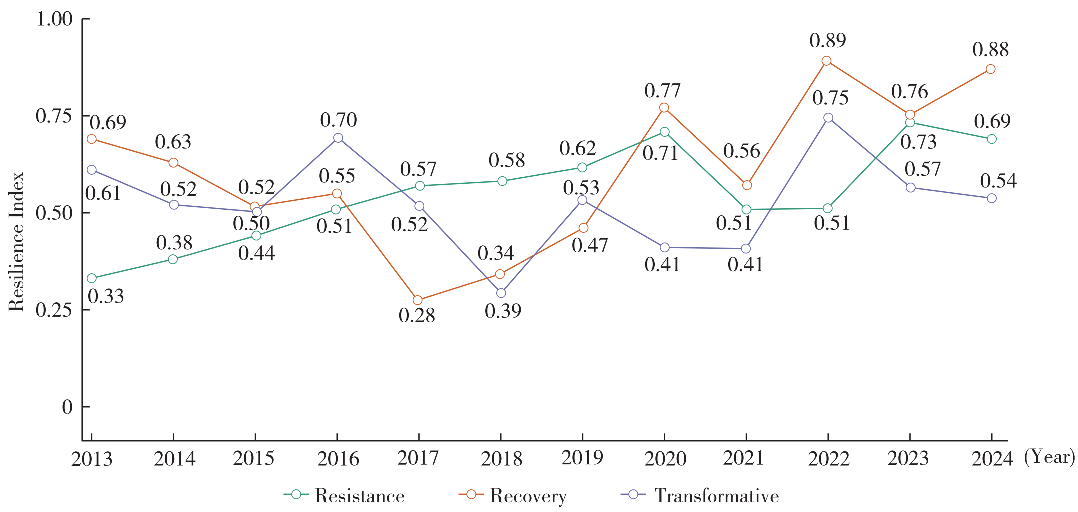
The second stage is the accelerated growth period from 2018 to 2022. The index rose rapidly from the low point of 0.48 in 2018 to 0.63 in 2022, with a total increase of 0.15 percentage points, registering the fastest growth rate among the three stages. The rapid growth was closely associated with two major external shocks. First, the COVID-19 pandemic in 2020 forced the rapid expansion of emergency capacity in warehousing and logistics, digital retail and food processing. Second, the government continued to increase investment in food security. The emergency storage and transportation network, cold chain system and green channel policies were gradually improved, which systematically enhanced the overall resilience of intermediate links.

The third stage is the high-level structural consolidation period from 2022 to 2024. After reaching a periodic peak of 0.70 in 2023, the index dipped slightly to 0.68 in 2024. This decline did not represent a substantive drop in resilience capacity. Instead, it was likely the combined effect of diminishing marginal returns of policy input in the post-pandemic era, declining utilization rate of some temporarily expanded emergency production capacity, and lingering uncertainties in international trade channels amid sustained geopolitical pressures. On the whole, the resilience index stabilized at a relatively high level and entered a phase of structural consolidation.

Overall, from 2013 to 2024, the resilience index of intermediate links traces a clear three-stage evolution: low-level accumulation to accelerated growth and then to stabilization at a high level. This trend reflected the continuous improvement of guarantee capacity of intermediate links in China's agrifood systems.

Based on the data of sub-indicators shown in Figure 3-9, the resistance capacity maintained a continuous upward trend, rising from 0.33 in 2013 to 0.69 in 2024 and serving as a fundamental pillar for system resilience. This change reflected the continuous expansion of warehousing capacity, cold chain facilities and inventory scale, which equipped the food supply chain with stronger short-term buffering capacity. Particularly around 2020, the resistance capacity climbed above 0.71, demonstrating that the system could maintain basic supply relying on inventory and logistics systems amid shocks. The recovery capacity experienced the most dramatic fluctuations and acted as the core driver of resilience changes. It stood at merely 0.34 in 2018,

Figure 3-9 Trends in the Dimensions of Resilience




**Source:** Calculated and compiled by the authors.

surged to 0.77 in 2020 and further hit a high of 0.89 in 2022, proving the system possessed strong recovery capacity against the pandemic and other external shocks. This was mainly attributed to the enhanced transportation scheduling, emergency processing capacity and policy intervention. In contrast, the transformation capacity showed notable fluctuations and remained weak on the whole, becoming a major weakness restricting the resilience of the current food supply chain. After reaching a periodic high of 0.75 in 2022, it dropped to 0.54 in 2024, indicating inadequate sustainability in the system's structural adjustment. Especially in the past two years, the import dependency and import volume of key agricultural products kept rising, with sources still concentrated in a handful of countries, which further accumulated supply risks. Under such circumstances, although supply stability can be maintained by virtue of recovery capacity in the short run, the growing reliance on and concentration of external markets will undermine the system's ability to cope with uncertainties in the long term.

## 3.4 Pathways for Resilience Building of Intermediate Links in Agrifood Systems

As illustrated in the above analysis, the intermediate links of China's agrifood systems operate with high efficiency while featuring prominent structural vulnerabilities. Therefore, the key to building food supply chain resilience does not lie in simply increasing inventory or expanding production capacity. Instead, centering on the three stages of resistance, recovery and transformation, relevant technologies, corporate strategies and governance mechanisms should be embedded into all key links to realize the systemic shift from passive response to proactive development (see Table 3-2 in the Appendix).

### 3.4.1 Warehousing and Logistics

In terms of resistance capacity, efforts should be made to strengthen basic reserves and channel buffering capacity. On the domestic front, continue to improve the multi-level reserve system consisting of central warehouses, regional warehouses and community nodes to expand coverage for fresh food and short-shelf-life products. For bottlenecks in international logistics, deploy overseas warehousing and transshipment facilities in major grain producing areas and key shipping nodes to create front-end buffers, so as to slow down the transmission of shocks when shipping lanes are blocked or ports are congested. In addition, establish monitoring mechanisms for energy price risks and early warning systems for freight fluctuations to adjust procurement and transportation schedules at the early stage of rising transport costs and mitigate cost impacts.

In terms of recovery capacity, build multi-channel alternative routes and intelligent scheduling capabilities. Integrate data from ports, railways, highways and customs clearance to establish an intelligent scheduling platform for multimodal transport. The platform can automatically generate alternative routes such as switching from sea freight to rail transport or combined sea-land transport when key shipping lanes are disrupted, so as to shorten the duration of transportation interruptions. Meanwhile, promote coordination between the green channel policy and railway and waterway systems. In the event of regional disasters or pandemic outbreaks, prioritize the cross-regional allocation of grain, edible oil and fresh products to achieve rapid reconnection of the transportation system.

In terms of transformation capacity, shift from static warehousing to data-driven global networked allocation. On the one hand, integrate inventory, logistics and consumption data via national supply chain information platforms to realize dynamic inventory allocation and risk early warning. On the other hand, upgrade warehousing facilities from a single storage function to integrated storage and transportation with emergency conversion capabilities. For example, deploy schedulable mobile cold storage units which operate for commercial logistics under normal conditions and serve as temporary reserve nodes in emergencies. Through the above transformation, the warehousing and logistics system can shift from capacity orientation to response orientation and substantially improve overall system resilience.

### 3.4.2 Food Processing

In terms of resistance capacity, enhance financial and inventory buffering capacity. Enterprises need to improve cash flow management, set minimum liquidity reserves and pre-secure credit lines to maintain financial stability against short-term shocks. Meanwhile, adopt tiered inventory management strategies. Maintain reasonable safety stocks for staple foods and reduce overstock risks for short-shelf-life products through high-frequency replenishment systems, so as to sustain basic production capacity amid supply and demand fluctuations.

In terms of recovery capacity, improve flexible production and product switching capabilities. Equip enterprises with modular production lines and digital process management systems to enable rapid switching between different products. For instance, divert part of production lines to manufacture staple foods or emergency foods when facing raw material shortages or surging demand. Such convertible production capacity can greatly shorten the time required for enterprises to resume normal supply after shocks and constitutes the core of recovery capacity in the processing sector.

In terms of transformation capacity, advance the shift from dedicated production to platform-based manufacturing systems. Deploy standardized production equipment with universal interfaces to break the linkage between production lines and single products. Digitize production processes and formula parameters of various products to build an accessible digital formula library, and support it with standardized quality inspection and rapid verification procedures to enable swift product switching. In addition, improve food safety traceability and information transparency mechanisms, embed quality control into the entire production process, and mitigate the impact of public opinion risks on the demand side.

### 3.4.3 International Trade

In terms of resistance capacity, prioritize strengthening information-based front-end buffering capacity. First, establish a comprehensive early warning system covering global agricultural markets, meteorological changes and shipping conditions to identify risks such as price volatility, extreme weather and transportation disruptions in advance, and provide decision support for enterprises and government authorities. Second, launch agricultural meteorological services and expert support mechanisms targeting key trading partners to help major supplier countries better cope with extreme weather shocks and reduce the likelihood of supply fluctuations at the source.

In terms of recovery capacity, leverage the dual support of diversified layout and regional coordination mechanisms. First, expand the number of importing countries and optimize procurement structures to build a diversified trade network with alternative routes. This enables the system to swiftly switch supply sources and restore basic supply when major suppliers or shipping lanes are disrupted. Second, draw on the experience of regional emergency food cooperation mechanisms such as the ASEAN Plus Three Emergency Rice Reserve, and realize cross-border emergency supply through the allocation of regional reserves amid sudden shocks to effectively shorten the duration of supply disruptions (see Box 3-2). Furthermore, enhance port and shipping capacity of key regional countries through transport capacity support and logistics coordination, so as to improve the overall recovery capacity of regional supply chains and shift the trade system from individual node recovery to network collaborative recovery.

In terms of transformation capacity, take multiple measures to address structural risks. On the demand side, develop alternative proteins and optimize feed formulas to gradually reduce rigid reliance on key imported agricultural products such as soybeans and cut off transmission channels of external shocks at the source. On the supply side, provide agricultural technical assistance, promote improved crop varieties and support production capacity building to help major supplier countries deliver more stable supply and consolidate the foundation of reliable international supply. Institutionally, take a more proactive role in formulating regional and multilateral trade rules. Focus on advancing institutional arrangements to guarantee trade continuity amid risks and shocks, including restrictions on export bans and the establishment of emergency trade lanes. Accelerate the development of digital compliance and standard adaptation systems to help enterprises respond promptly to rule changes in different markets.

### 3.4.4 End Retail

In terms of resistance capacity, priority should be given to guaranteeing minimum food supply when delivery capacity is constrained. In cases of delivery rider shortages, platform scheduling failures or local traffic disruptions, physical local outlets such as community supermarkets and farmers' markets shall serve as basic supply nodes. Volunteer delivery teams and temporary staffing can be mobilized to fill delivery gaps and build alternative supply channels independent of online platforms, so as to sustain uninterrupted access to essential food.

In terms of recovery capacity, it is critical to enhance

**Box 3.2** Operational Models and Expansion Paths of Regional Collaborative Mechanisms for Emergency Food Security

To address regional food crises and supply shocks, the Association of Southeast Asian Nations Plus China, Japan and the Republic of Korea (ASEAN+3) established the ASEAN Plus Three Emergency Rice Reserve (APTERR) in 2011. Centered on decentralized reserves, unified coordination and emergency allocation, this mechanism builds a regional food security network through joint financial contributions or in-kind commitments from member states.

In terms of scale and operation, APTERR features three major attributes. First, it has a clear and well-targeted reserve scale. The total rice reserve committed by member states stands at approximately 780,000 metric tons, which can fully meet the demand for short-term disaster relief. Second, it delivers rapid response. A secretariat under the mechanism takes charge of coordination, and the allocation and transportation arrangements can generally be completed within several weeks after an application is submitted by a member state. Third, it prioritizes humanitarian assistance. It has provided emergency food supplies on multiple occasions to the Philippines, Laos, Cambodia and other countries hit by typhoons and floods, effectively alleviating local food shortages and price fluctuations.

The operation of APTERR further proves that regional food security does not solely rely on large-scale physical reserves. Its core lies in building mobilizable supply capacity. Reserves committed by member states under this mechanism are not necessarily stored in a centralized manner. Instead, institutional agreements and coordination frameworks help form virtual reserves or mobilizable reserves, which can be rapidly activated and converted into tangible supply capacity once shocks occur. This model not only cuts long-term warehousing costs and reduces food losses, but also improves response efficiency in emergencies.

On this basis, China can promote the expansion and upgrading of similar mechanisms within the framework of the Belt and Road Initiative. On the one hand, build regional emergency reserve networks for food and feed grains in key grain-producing areas across Central Asia, Southeast Asia and Africa, and gradually expand the existing rice-focused mechanism to cover feed grains such as corn and soybeans. On the other hand, strengthen agricultural cooperation including improved seed promotion and cultivation technology support to enhance the stable supply capacity of countries along the routes, and establish a dual guarantee system combining reserves and production capacity. Meanwhile, develop digital platforms to share information on inventory, logistics and demand, so as to improve the efficiency of regional emergency allocation.

the rapid restructuring capacity of delivery and order fulfillment networks. Cross-regional deployment of delivery staff, mobilization of social transport resources, and information and operational collaboration among different platforms enable dynamic circulation of orders and inventories and prevent systemic supply disruptions caused by the failure of a single platform. During the COVID-19 pandemic, when logistics services were partially suspended in Shanghai and other cities, platform enterprises represented by JD.com rapidly allocated warehousing and delivery resources from other regions and transferred off-site inventories to local markets, effectively easing short-term supply shortages. This practice indicates that fulfillment networks with cross-regional resource integration capabilities can quickly re-establish connections among personnel, goods and operating networks after shocks, which constitutes the core support for the recovery resilience of end supply systems.

In terms of transformation capacity, targeted subsidies and basic livelihood security arrangements shall be adopted in distribution mechanisms to improve food access for low-income and vulnerable groups and prevent stratified supply shortages amid tight supply. The development of last-mile logistics in underdeveloped regions shall be incorporated into long-term infrastructure investment to remedy spatial supply deficiencies and strengthen overall system resilience. Supervision over platform algorithms and market concentration shall be intensified to guard against algorithmic price discrimination and platform monopolies, and mitigate the impact of individual platform failures on system stability.

## Appendix

### A3.1 Core Indicators of Resilience Capacity Index for Intermediate Links

This chapter constructs the resilience capacity index for intermediate links from three dimensions: resistance capacity, recovery capacity and transformation capacity. Resistance capacity mainly reflects the buffering capacity of food supply chains when shocks occur, focusing on processed goods inventory, cold storage capacity, inventory buffer ratio, as well as fluctuations in import prices, transportation costs and energy prices. Recovery capacity represents the ability of supply chains to resume normal operation after shocks, with selected indicators including profits of the food processing industry, comprehensive freight capacity and fluctuations in food-related Consumer Price Index. Transformation capacity refers to the ability of supply chains to mitigate long-term

**Appendix Table 3-1 Key Technologies and Strategies for Building Resilience in the Intermediate Stages of the Agrifood Systems**

| Components | Warehousing and Logistics | Food Processing | International Trade | Terminal Retail |
|---|---|---|---|---|
| Resistance | • Multi-level reserve system (central warehouse-regional warehouse-community node);<br>• Overseas warehouses and pre-layout of key nodes;<br>• Monitoring and early warning system for freight rates and energy prices | • Cash flow and credit reserve mechanism;<br>• Tiered inventory management (safety stock + high-frequency replenishment);<br>• Priority guarantee strategy for basic food | • Early warning system for global agricultural product market and shipping risks;<br>• Agricultural meteorological monitoring and forecasting platform;<br>• Production risk assessment system for source countries | • Community physical network (supermarkets/ farmers' markets) as backup supply nodes;<br>• Non-platform delivery (voluntary/ temporary organizations);<br>• Basic food security mechanism |
| Recovery | • Multi-channel transportation substitution (shipping-railway-land-sea combined transport);<br>• Intelligent scheduling platform for multimodal transport;<br>• Green channel and traffic priority guarantee mechanism | • Modular production lines;<br>• Flexible manufacturing system; digital process management (rapid production conversion);<br>• Emergency food production capacity | • Diversified import sources;<br>• Regional emergency reserve mechanism (e.g. regional grain reserves);<br>• Cross-border logistics coordination and capacity allocation | • Cross-regional delivery scheduling;<br>• Multi-platform collaborative fulfillment system;<br>• Social transport capacity access mechanism;<br>• Dynamic matching system for inventory and orders |
| Transformation | • Global supply chain data platform (integration of inventory, logistics and demand);<br>• Intelligent warehousing and dynamic allocation system;<br>• Integration of mobile cold chain and emergency storage and transportation | • Platform-based manufacturing system (standardized equipment + universal interfaces);<br>• Digital formula library;<br>• Food safety traceability system; quality transparency mechanism | • Diversified layout of import sources;<br>• Alternative protein and feed optimization technology;<br>• Overseas agricultural cooperation and production capacity building;<br>• Digital trade rule adaptation system | • Algorithm supervision and fair pricing mechanism;<br>• Subsidy system for vulnerable groups;<br>• Balanced layout of urban and rural logistics infrastructure;<br>• Platform anti-monopoly and data governance |

**Source:** Compiled by the authors.

**Appendix Table 3-2 Indicator System for Food Supply Chain Resilience**

| Component | Indicator | Direction | Data Source |
|---|---|---|---|
| Resistance | Inventory Scale of Food Processing Industry | + | National Bureau of Statistics of China, Wind Database |
| | Cold Storage Capacity | + | China Storage & Distribution Association |
| | Fluctuation of Agricultural Product Import Prices | – | Calculated from UN Comtrade |
| | Fluctuation of Baltic Dry Index (BDI) | – | Baltic Exchange |
| | Fluctuation of World Crude Oil Prices | – | International Energy Agency, UN Comtrade |
| | Inventory Buffer Ratio (Inventory / Profit) | + | National Bureau of Statistics of China, Wind Database |
| Recovery | Profit of Food Processing Industry | + | National Bureau of Statistics of China, Wind Database |
| | Comprehensive Freight Capacity | + | National Bureau of Statistics of China |
| | Fluctuation of Food CPI | – | National Bureau of Statistics of China |
| Transformation | Number of Food Processing Enterprises | + | National Bureau of Statistics of China, Wind Database |
| | Import Dependence of Agricultural Products | – | UN Comtrade, National Bureau of Statistics of China |
| | Import Source Concentration of Agricultural Products (HHI) | – | Calculated from UN Comtrade |
| | Risk Concentration Index (Dependence × HHI) | – | Calculated from UN Comtrade |
| | Change Rate of Import Dependence | + | Calculated from UN Comtrade |

risks through structural adjustments, mainly covering the number of processing enterprises, import dependency, import source concentration and their changing trends. Overall, this indicator system can reflect the resilience level of intermediate links of food supply chains in processing, warehousing, logistics and trade.

## A3.2 Methodology for Resilience Capacity Index for Intermediate Links

Based on the above indicator system, this report further develops a comprehensive resilience index for food supply chains to systematically evaluate the overall resilience and evolutionary trends of intermediate links in China's agrifood systems. Given the differences in dimension, value range and economic implications among individual indicators, the index construction consists of three major steps: indicator standardization, dimensional aggregation and comprehensive weighting.

First, all indicators are processed with dimensionless treatment to eliminate the impact of inconsistent dimensions. Range standardization is adopted for linear transformation of positive indicators, where a higher value indicates stronger resilience.

Reverse standardization is applied to negative indicators, where a higher value implies greater system vulnerability, so that their numerical trends are aligned with those of positive indicators. After processing, all indicators are scaled to the range of [0, 1] for comparability. Second, in terms of dimensional construction, in accordance with the analytical framework of resistance capacity, recovery adjustment and structural adaptation, standardized indicators are classified into three sub-dimensions namely absorption capacity, recovery capacity and adaptation capacity. Equal-weight averaging is adopted for aggregation within each dimension. This approach avoids subjective bias and ensures balanced contributions of individual indicators within the same dimension, so as to objectively reflect the overall performance of the system in different capacity categories. Third, the expert weighting method is used to determine the weight of each dimension for the construction of the comprehensive index. Specifically, 35 experts specializing in agricultural economics, supply chain management and industrial policy were invited to score the importance of absorption capacity, recovery capacity and adaptation capacity for food supply chain resilience. Average weights are calculated based on expert scores. The results show that absorption capacity plays a fundamental and preemptive role in addressing short-term risks. Recovery capacity and adaptation capacity reflect the system’s adjustment efficiency and long-term structural optimization capability respectively. According to expert evaluations, the final weights of absorption capacity, recovery capacity and adaptation capacity are set at 0.40, 0.30 and 0.30 respectively.

To enhance the robustness and interpretability of the index, the three-period rolling standard deviation is used to smooth some volatile indicators, and moving average processing is applied to the final index to reduce the interference of extreme values on trend judgment. Meanwhile, range standardization is adopted to scale all indicators to the range of [0, 1] with a unified measurement scale, and a higher value represents stronger system resilience. The resilience index established via the above methods can comprehensively reflect the stability, recovery capacity and structural adaptability of food supply chains under various shock scenarios, and provide quantitative support for subsequent trend analysis and policy evaluation.

## References


Guangming Online. China Has Basically Established a Whole-Chain Grain Emergency Support System (in Chinese) [EB/OL]. (2023-05-12) [2026-05-27]. https://m.gmw.cn/2023-05/12/content_1303371643.htm.

Guosen Securities. Instant Retail Industry Report (I): Competitive Landscape, Platform Competition, and the Impact on Major Companies' Profits (in Chinese) [R]. Shenzhen: Guosen Securities, 2025. https://pdf.dfcfw.com/pdf/H3_AP202507221713451853_1.pdf.

The State Council Information Office of the People's Republic of China. National Food and Strategic Reserves Administration Holds a Press Briefing on Technological Innovation in Grain Circulation (in Chinese) [EB/OL]. (2025-06-08) [2026-05-27]. http://www.scio.gov.cn/xwfb/bwxwfb/gbwfbh/lshwzcbj/202506/t20250608_899305.html.

National Food and Strategic Reserves Administration. China's National Food Security Has Been Effectively Safeguarded (in Chinese) [EB/OL]. (2025-10-14) [2026-05-27]. https://www.gov.cn/lianbo/bumen/202510/content_7044424.htm.

Ministry of Transport of the People's Republic of China. Interpretation of the Notice on Further Improving the Service Level of the "Green Channel" Policy for the Transportation of Fresh Agricultural Products (in Chinese) [EB/OL]. (2023-01-20) [2026-05-27]. https://www.gov.cn/govweb/zhengce/2023-01/20/content_5738216.htm.

Jiang, H. Research on the Pathways and Value of Deep Integration Between E-commerce and Rural Revitalization (in Chinese) [J]. E-Commerce Letters, 2025, 14(12): 1228–1236. https://doi.org/10.12677/ecl.2025.14123982.

Xi Jinping Economic Thought Research Center. Keeping Maritime Economic Arteries Open to Support the Building of a Strong Maritime Nation (in Chinese) [EB/OL]. (2024-08-19) [2026-05-27]. https://www.ndrc.gov.cn/wsdwhfz/202408/t20240819_1392465.html.

Ministry of Agriculture and Rural Affairs of the People's Republic of China. China Agricultural Products Cold Chain Logistics Development Report (2024) Shows: Bridging the "First Mile" Gap and Advancing High-Quality Development (in Chinese) [EB/OL]. (2025-08-28) [2026-05-27]. https://scs.moa.gov.cn/sclt/202508/t20250828_6476791.htm.

China International Electronic Commerce Center, Ministry of Commerce. China Online Retail Market Development Report 2023 (in Chinese) [R]. Beijing: China International Electronic Commerce Center, Ministry of Commerce, 2024.

Xinhua News Agency. Livelihood Express: Food Delivery Observation—More Than 10 Million Delivery Riders on the Move (in Chinese) [EB/OL]. (2025-01-16) [2026-05-27]. https://www.news.cn/politics/20250116/76ec3cf62fb7416aa7abd94938bc078e/c.html.

Xu, K. Accelerating High-Quality Development of the Food Industry (in Chinese) [EB/OL]. (2025-04-17) [2026-05-27]. https://www.drc.gov.cn/DocView.aspx?chnid=378&leafid=1338&docid=2908415.

Cold Chain Logistics Committee, China Federation of Logistics and Purchasing. China Cold Chain Logistics Development Report (2025) (in Chinese) [R]. Beijing: Cold Chain Logistics Committee, China Federation of Logistics and Purchasing, 2025.

# Chapter 4

# Building Consumer-Side Nutrition Resilience: Transmission, Intra-household Allocation, and Targeted Policy Interventions

WANG Jingjing[1], XIE Xiaofei[1], PAN Hui[1], NI Lijie[1], XIA Jiayu[1], GAO Haixiu[2], XING Li[1], ZHAO Qiran[1], and FAN Shenggen[1]

1. Academy of Global Food Economics and Policy, China Agricultural University
2. Institute of Food and Nutrition Development, Ministry of Agriculture and Rural Affairs

## Key Findings

- Intra-household resource allocation is a critical mechanism for ensuring individual nutrition security. Existing policy frameworks usually measure nutrition resilience at the household level; this implicitly assumes equal resource distribution but obscures the systemic effects of gender and intergenerational dynamics. Even households with adequate aggregate resources may fail to ensure nutrition security for vulnerable members.
- Shocks are transmitted and amplified through four pathways: affordability, accessibility, nutrition awareness, and intra-household resource allocation (4As). Their impacts are concentrated among vulnerable groups such as left-behind children, older adults living alone, pregnant and breastfeeding women, and migrant populations. These mechanisms reinforce one another, creating a vulnerability trap that is difficult to break through with a single policy intervention. For infants, young children, and pregnant or breastfeeding women in critical life windows, nutrition losses during shocks are often irreversible and do not automatically recover as markets stabilize.
- China already has the institutional foundation for baseline guarantees. The next step is to shift from ensuring minimum subsistence to providing nutrition-oriented protection. To ensure that everyone has stable access to nutritious diets at all times, existing social safety-net policies should be strengthened in three respects: clarifying nutrition-oriented protection objectives, targeting nutritionally vulnerable individuals, and developing more proactive shock-response mechanisms.

## Policy Recommendations

● Upgrade social safety-net and emergency reserve systems with nutrition protection as the guiding objective, so that the basic dietary nutrition of vulnerable groups is not compromised during shocks. This requires three policy adjustments: first, introducing targeted food vouchers that can be used for nutrient-dense foods and distributed preferentially to primary household caregivers; second, relaxing hukou-based restrictions to include migrant populations in emergency relief; and third, upgrading emergency reserves from staple grains to comprehensive nutrition inventories, supported by rapid deployment protocols for specialized nutrition packages for infants, young children, pregnant women, lactating women, and other groups in critical life windows. Together, these measures can reduce the risk of irreversible nutrition damage caused by short-term shocks.

● Optimize the food environment and scale up nutrition education to strengthen residents' capacity to obtain and consume nutritious foods. Put the "Big Food Concept" into practice by expanding policy support from staple grains to non-staple grains, fruits, vegetables, and other crops, thereby developing nutrition-oriented agriculture. Deliver differentiated nutrition education for key populations, with a focus on improving the nutrition decision-making capacity of family caregivers, especially rural women. Develop short-chain agricultural-product logistics models to improve local access to fresh food; at the same time, retain and strengthen offline acquisition channels such as community retail outlets to bridge the digital divide in food access.

● Promote a triple transition in nutrition resilience policy: from subsistence-focused support to nutrition-centered protection, from household-level targeting to interventions for nutritionally vulnerable individuals, and from reactive emergency response to proactive risk prevention. Nutrition resilience should be systematically integrated into the Healthy China Initiative. Childhood nutrition interventions should be extended to the preschool stage, and elderly meal assistance should be incorporated into the regular basic public service system. At the same time, cross-departmental data barriers should be removed to establish a dynamic monitoring system for nutrition resilience at both household and individual levels, supported by coordinated mechanisms for nutrition monitoring, early disease warning, and timely intervention.

## 4.1 Introduction

Nutrition security is the cornerstone of human health and social development. At present, the nutrition health of China's population is undergoing a profound structural transition: undernutrition and micronutrient deficiencies have not been completely eliminated, while overweight, obesity, and associated chronic diseases continue to rise, forming a typical double burden of malnutrition (Popkin et al., 2020; National Health Commission, 2020). Driven by the rapid development of the food industry, modern logistics, and digital platforms, residents' dietary structures are changing quickly. Ultra-processed foods, takeaway meals, and ready-to-eat packaged foods have improved food accessibility, but their widespread consumption has also introduced new nutrition risks (FAO et al., 2023; China Internet Network Information Center, 2024). This transition exposes systemic vulnerabilities, especially when supply chains are disrupted, food prices fluctuate, or household incomes decline. Families and individuals in disadvantaged food environments or under financial constraints are often the first to face nutrition insecurity (FAO, 2016; Headey and Ruel, 2022). Therefore, how to effectively safeguard individual nutrition security amid growing uncertainty has become an urgent issue for both China and the global community.

The impact of shocks on nutrition security is multilayered. Community-level food environments determine what foods can be obtained; household finances and asset reserves shape how much can be bought; and intra-household resource allocation ultimately determines who gets what. A break at any point in this chain weakens individual nutrition resilience. However, existing research and policy frameworks mostly focus on nutrition status at the household level and assume that intra-household resources are distributed equally. This masks unequal nutrition distribution within households and systematically obscures the true nutrition status of vulnerable members. Accordingly, household-targeted policy interventions rest on an untested foundational assumption: that household food resources will be allocated equitably among all individuals. Numerous studies show that gender norms, intergenerational power hierarchies, and cultural conventions systematically distort this process, making the equal-distribution premise empirically untenable (Haddad et al., 1996; Quisumbing and Maluccio, 2003). Enhancing overall household nutrition resilience is not equivalent to guaranteeing the nutrition security of the most vulnerable individuals within a household. For infants, young children, and pregnant and breastfeeding women in critical life windows, nutrition shortfalls during shocks often cause irreversible damage to cognitive development, physical health, and long-term human capital (Alderman et al., 2006; Bhutta et al., 2013). Such losses cannot be fully reversed through subsequent dietary recovery. Strengthening nutrition resilience should therefore go beyond household-level food sufficiency and ensure that nutritionally vulnerable individuals have stable access to nutrient-adequate diets before, during, and after shocks.

Recognizing that household-level resilience does not necessarily translate into individual nutrition security, this chapter extends the analysis of nutrition resilience to the individual level and incorporates intra-household allocation into the analytical framework. The analysis addresses three core questions: first, how do different types of shocks ultimately affect individual nutrition by influencing household purchasing power, food acquisition channels, nutrition knowledge, and intra-household allocation? Second, which groups are most vulnerable under shocks, and what are the root causes of their vulnerability? Third, how can policy design be optimized to systematically strengthen nutrition resilience, especially to safeguard the nutrition security of vulnerable individuals? China's real-world context makes these questions especially urgent. As population aging deepens and family structures continue to change, household forms such as older adults living alone, skip-generation care, and left-behind families have become increasingly common (Jin and Liu, 2017; Shi et al., 2025). The gap between overall household resilience and individual nutrition security has become increasingly prominent. Consequently, a policy transition that penetrates the household unit and precisely protects the nutrition resilience of vulnerable individuals has become urgent.

This chapter is organized as follows. First, it constructs a multidimensional theoretical framework for nutrition resilience. Second, it systematically analyzes the key transmission pathways through which shocks affect nutrition resilience. Third, by reviewing international experience and Chinese practice, it evaluates the effectiveness and challenges of the current policy system. Finally, based on China's national conditions, it proposes differentiated intervention pathways and policy recommendations oriented toward both households and individuals.

## 4.2 Theoretical Analytical Framework of Nutrition Resilience

### 4.2.1 Definition of Nutrition Resilience

"Nutrition resilience" is usually defined as the capacity of households or individuals, when facing shocks and stresses, to effectively utilize existing resources and capabilities to maintain or rapidly recover their nutrition status (FAO, 2014; Fan et al., 2014). This definition encompasses three dimensions: absorptive capacity, which is the ability to utilize existing resources to withstand short-term shocks and maintain basic nutrition intake (Hendriks, 2015); adaptive capacity, which is the ability to adjust livelihood strategies and resource use patterns to cope with persistent stresses (Bailey et al., 2019); and transformative capacity, which is the ability to fundamentally change food sources and acquisition methods while maintaining or improving nutrition status when facing severe or long-term shocks (Muricho, 2018; FAO, 2016).

To understand the meaning of nutrition resilience, it is necessary to clarify the boundaries between two sets of concepts. The first is nutrition security versus nutrition resilience. Nutrition security focuses on a static condition, namely that "all people, at all times, have physical and economic access to sufficient, safe and nutritious food" (FAO, 2016); nutrition resilience extends resilience theory into the nutrition domain and emphasizes dynamic capabilities, that is, the process of maintaining or rapidly recovering good nutrition status when shocks occur (UNICEF, 2023). The former is a policy goal, while the latter is the systemic capacity to achieve that goal. The second is resilience versus vulnerability. The two are not simply opposites: vulnerability research focuses on whether shocks push people into poverty, whereas resilience research asks whether shocks or stresses produce long-term negative consequences (Fan et al., 2014). This distinction implies that even if a household does not fall into poverty, the nutrition status of its members may still suffer persistent damage because coping capacities are insufficient.

Building on this framework, this chapter further extends the unit of analysis from the household to the individual. Nutrition needs vary significantly among family members. The nutrient requirements of young children, older adults, and pregnant and breastfeeding women differ from those of average adults (Haddad et al., 1996; Fan et al., 2014). Yet intra-household resource allocation does not always follow nutrition need; rather, it is often shaped by gendered bargaining power, generational hierarchies, and cultural norms (Haddad et al., 1996; Quisumbing and Maluccio, 2003). The combination of heterogeneous individual nutrition needs and unequal, non-need-based household resource allocation makes it difficult for aggregate household nutrition status to accurately reflect the actual intake of individual members. This means that household-based resilience indicators, such as the Household Dietary Diversity Score (HDDS) and the Coping Strategy Index (CSI), may systematically obscure the nutrition status of vulnerable family members.

Accordingly, this chapter defines nutrition resilience as: the dynamic ability and process by which individuals, when facing various shocks, can effectively mobilize internal and external household resources and adjust food acquisition and consumption strategies to maintain adequate, diverse, and nutritionally balanced dietary intake at all times. This definition has three implications: first, the unit of analysis focuses on the individual rather than the household, as the household is the site of resource aggregation and allocation, but nutrition outcomes are ultimately manifested at the individual level; second, it emphasizes a dynamic process rather than a static state, where resilience is a systemic capacity that varies with the type and intensity of shocks; third, it encompasses both quantitative and qualitative dimensions, focusing not only on the adequacy of energy intake but also emphasizing dietary diversity and micronutrient adequacy levels.

### 4.2.2 The 4A Analytical Framework of Nutrition Resilience

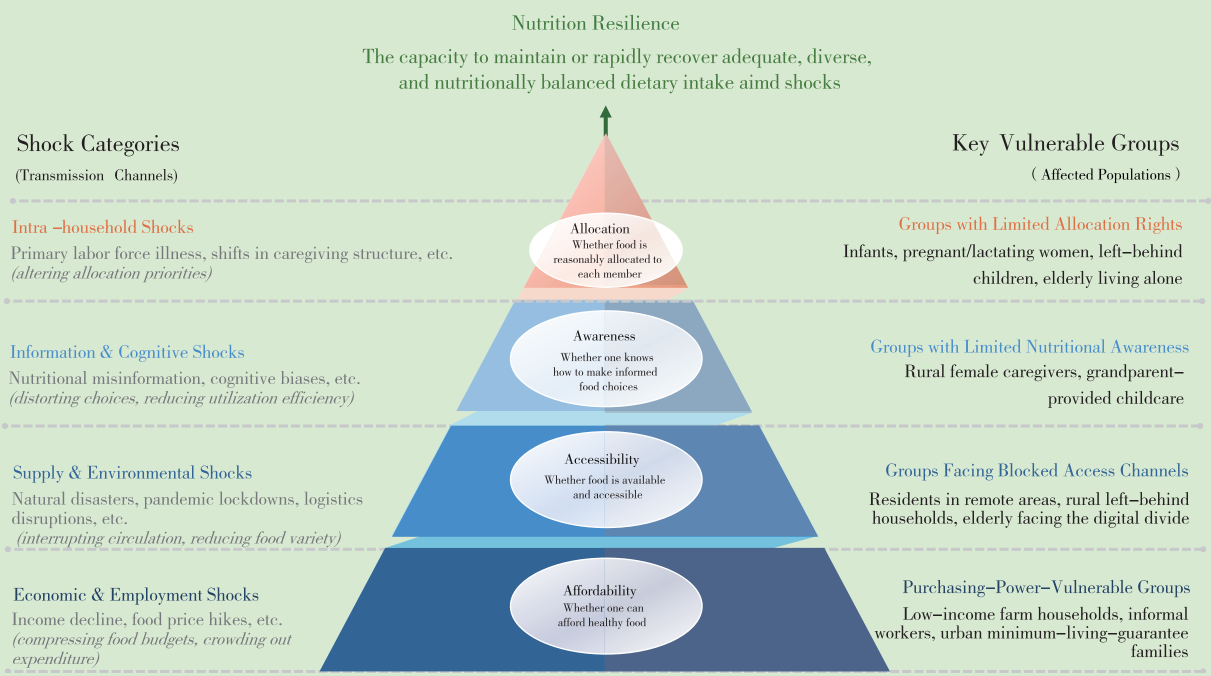
This study summarizes the key pathways through which shocks affect nutrition resilience in the "4A Analytical Framework": Affordability, Accessibility, Awareness, and Allocation. Within this framework, affordability, accessibility, and nutrition awareness form a stepwise sequence: households must first be able to afford food, then be able to access it, and finally be able to make nutritionally appropriate choices. Together, these three dimensions determine a household's overall capacity to obtain food and maintain dietary quality. Intra-household food allocation differs from the other three dimensions. It cuts across all of them and serves as a core mediating mechanism, amplifying or buffering the effects of impaired purchasing power, constrained access channels, and insufficient nutrition awareness on individual nutrition. Ultimately, it determines whether household food resources are distributed reasonably among different members. Therefore, intra-household food allocation is the decisive mechanism through which nutrition improvements reach, or fail to reach, vulnerable individuals.

In general, the impacts of different types of external shocks on nutrition resilience often exhibit pathway heterogeneity; for example, income fluctuations and food price hikes primarily weaken affordability, supply chain disruptions and extreme weather mainly undermine accessibility, and misinformation and cognitive biases primarily interfere with nutrition awareness, while household caregiving structures and gender power norms, acting through the intra-household allocation mechanism, run through and regulate the ultimate impacts of the other three dimensions on individual nutrition. Such differentiated transmission mechanisms produce heterogeneous patterns of nutrition vulnerability across groups. The 4A analytical framework not only clearly delineates the specific pathways through which shocks impair individuals' nutrition intake capacities but also provides a direct basis for differentiated policy interventions aimed at enhancing individual nutrition resilience.

## 4.3 Transmission Mechanisms Affecting Nutrition Resilience

The following four sections analyze the pathways and transmission mechanisms through which external shocks weaken individuals' ability to obtain and consume nutritious foods. The discussion proceeds dimension by dimension along the 4A framework and identifies the key nutritionally vulnerable groups under each dimension. Section 4.3.5 further analyzes the interactions and compounding effects of the four mechanisms.

**Figure 4-1 The 4A transmission pathway framework of shocks affecting nutrition resilience**




**Source:** Compiled by the authors.

### 4.3.1 Affordability

Affordability refers to the family's ability to afford healthy foods, which directly determines the household's space of choice and bargaining power in the food market. Income shocks, price inflation, and financial pressures caused by illness can significantly weaken the household's food affordability; all three force households to make difficult trade-offs between food quantity and quality by compressing the actual food budget, thereby affecting the nutrition resilience of family members.

First, a decline in income is the most direct source of shocks weakening affordability. A decline in income forces households to reallocate limited budgets across multiple expenditures, such as food, housing, medical care, and education. For low-income families with high Engel coefficients, dietary quality is often the first to be sacrificed (Stillman and Thomas, 2008). They tend to shift toward cheap, energy-dense but nutrient-poor foods, such as highly processed staples and fats, while reducing their intake of nutrient-dense foods, including fresh fruits, vegetables, and high-quality proteins. As a result, dietary diversity declines, micronutrient intake becomes insufficient, and the risk of "hidden hunger" increases (Hinks and Leckie, 2017). Based on panel data from Bangladesh, Akter and Basher (2014) found that under the dual shocks of rising food prices and declining incomes, the caloric intake of low-income households dropped by 12% and their dietary diversity scores decreased by 18%, failing to recover within six months post-shock. Furthermore, facing severe income shocks, households may also reduce daily meal frequencies or even sell productive assets (such as farm tools and livestock) to maintain current food consumption. Although asset sales can temporarily alleviate consumption difficulties in the short term, they directly impair the household's future income-generating capacity, thereby plunging them into a vicious cycle of "shock → asset depletion → exacerbated vulnerability" (Giannopoulos and Naouma, 2019). In rural China, although land transfer proceeds and migrant work income constitute important buffering mechanisms for households to cope with shocks, for agriculture-dependent households or vulnerable families relying mainly on informal employment, their buffering capacity against shocks is highly limited (Zhu and Li, 2023).

Second, food price fluctuations and rising costs undermine affordability. Unlike income shocks, food price increases are market-side shocks that directly erode the household's actual purchasing power. Even if income remains unchanged, price hikes equally force households to abandon foods with high nutrition value but high prices and turn to cheaper substitutes, resulting in a structural decline in dietary quality. Generally, factors such as supply shortages, demand panic, and speculative manipulation often drive up food prices; among these, the price fluctuations of perishable foods that are difficult to store and transport, such as fresh fruits, vegetables, and animal-based foods, are often more severe, thus exposing low-income families to greater risks of nutrition loss. Research from Bangladesh found that while the long-term impacts of price fluctuations tend to equalize across groups following market adjustments, in the short term, the rise in rural food prices causes significant shocks to farmers' food security, and this impact is particularly pronounced for asset-poor households (Akter and Basher, 2014). It should be noted that if price hikes originate from structural causes such as supply chain disruptions or poor regional circulation, they concurrently serve as signals of impaired accessibility.

Third, the erosive effect of disease shocks on nutrition resilience is often underestimated; such shocks often become a key mechanism affecting the nutrition resilience of households and individuals by squeezing out the food expenditure budget. Illness among family members simultaneously brings two types of financial pressures: on the one hand, a sharp increase in medical expenditures directly crowds out the food budget; on the other hand, the loss of labor capacity of the primary labor force due to illness leads to a decline in household income. Compounded together, their impact on affordability is often more severe and involves a longer recovery period than short-term income fluctuations (Goudge and Govender, 2007). In rural China, poverty due to illness is one of the most common triggers for the collapse of household nutrition resilience; the crowding-out effect of medical expenditures hits the food budget first, forcing families to make painful trade-offs between medical care and nutrition (Chen and Zhao, 2012). By weakening affordability, the three aforementioned types of shocks trigger a process of intra-household resource reallocation: when resources are tight, vulnerable members often bear the brunt of nutrition cutbacks first.

### 4.3.2 Accessibility

Accessibility refers to the family's ability to acquire food through market, circulation, and distribution systems. Even with purchasing power, if food acquisition channels are blocked or supply is scarce, households may still face the dilemma of "having money but unable to buy food" or "the available food is of low nutrition value". Food environments therefore directly shape accessibility. The supply conditions, circulation channels, and market structures of food surrounding the household determine whether the family can acquire sufficient food, as well as the nutrition quality of the food they can acquire (Swinburn et al., 2013; Herforth and Ahmed, 2015).

First, production losses and supply chain disruptions triggered by multiple external shocks can significantly weaken food accessibility. Natural disasters not only directly impair agricultural production but may also damage transportation infrastructure, disrupting the movement of food across regions (Akter and Basher, 2014). Lockdowns and logistics bottlenecks during major pandemics, together with policy shocks such as trade restrictions, can likewise produce structural food shortages. As supply contracts, the range of foods available to consumers shrinks, leaving households with fewer dietary choices and reducing dietary diversity (Opiyo et al., 2021; Merchant et al., 2022).

Second, weak infrastructure, geographic isolation, and the digital divide further constrain food accessibility. In remote rural areas and urban "food deserts," fragile retail and distribution networks make it harder for households to obtain food in person. For instance, differences in cold-chain logistics help explain why fresh milk intake among rural children is significantly higher in Zhejiang than in Guizhou (Xia, 2022), while dietary diversity scores among children in remote western regions are only 60–70 percent of those observed in urban areas (FAO, 2016). Although digital food-purchasing channels can partly overcome geographic isolation, they may also create new barriers for older adults and less-educated groups who have limited access to, or familiarity with, digital technologies. As a result, vulnerable groups may face even greater difficulty obtaining food during shocks or periods of disruption (Liu et al., 2024).

Third, structural imbalances in food supply lead to a decline in the accessibility of healthy foods. In many low-income communities and rural areas, the accessibility of healthy versus unhealthy foods exhibits obvious asymmetry; pre-packaged, high-sugar, and high-fat foods are often lower in price, more widely distributed, and easier to obtain, whereas the density of supply points for nutrient-dense foods like fresh fruits, vegetables, and high-quality proteins is significantly lower, forming a structural "nutrition access gap" (Popkin et al., 2020). Even in regions where the total food supply is adequate, if the combination of foods available on the market is dominated by low-nutrient-density items, households may formally "be able to buy" food but are substantively unable to acquire sufficient nutrition, thus similarly suffering systemic damage to their dietary quality. This issue is particularly prominent in China; with the rapid expansion of ultra-processed foods, takeout, and pre-packaged meals, the convenience of food acquisition has greatly improved, but the accompanying nutrition risks are equally not to be ignored (FAO et al., 2023; China Internet Network Information Center, 2024).

### 4.3.3 Nutrition Awareness

Nutrition knowledge refers to the scientific understanding by households and individuals regarding healthy dietary principles, the nutrition value of foods, and the associations between nutrition and chronic diseases; it is the core internal driving factor determining household and individual dietary behaviors and enhancing their nutrition resilience (Worsley, 2002; FAO, 2016). Under equivalent income and food environment conditions, the nutrition intake of households with high nutrition knowledge is significantly superior to that of households with lower nutrition knowledge (Diansari, 2014; Ruel and Alderman, 2013).

First, a higher level of nutrition awareness effectively buffers the loss of dietary quality under budget constraints. Households with higher levels of nutrition knowledge are more inclined to allocate their food budgets across diverse food categories rather than solely pursuing energy provision, thereby achieving higher nutrition intake quality at the same expenditure level (Diansari, 2014). This capability is especially important when economic shocks lead to budget tightening; rather than blindly cutting food consumption or shifting to low-quality cheap foods, households maintain dietary balance through nutrition-oriented budget adjustments (Montalbano and Romano, 2023). Empirical studies show that low-income families who have received nutrition education maintain significantly higher dietary diversity following income shocks compared to control groups without such interventions, indicating that cognitive interventions can enhance household nutrition resilience without requiring additional economic resources (Ruel and Alderman, 2013).

Second, the enhancement of nutrition awareness helps improve the efficiency of converting food resources into actual nutrition intake. Even if food is accessible, lack of awareness may still cause households to make low-nutrition choices among available options, or lead to substantial nutrient loss due to improper storage and cooking methods, resulting in actual nutrition intakes falling far below potential levels. Elevated nutrition awareness can help households identify nutrient-dense foods and master scientific storage and cooking methods, enabling them to maintain or improve overall nutrition intake through knowledge-driven food management strategies (e.g., diversified planting, scientific stockpiling, and rational combinations) even under constrained food choice scenarios (Di Stefano et al., 2022; Frankenberger and Nelson, 2023). Research indicates that incorporating nutrition education modules into food and agriculture-based resilience-building programs can significantly enhance the nutrition quality of household food production, improve food utilization efficiency, and optimize infant and young child feeding practices (Campbell et al., 2013; Chimeli and Shogren, 2015; IFPRI, 2020).

Third, the enhancement of nutrition awareness can optimize coping strategies and nutrition outcomes in shock scenarios. Families lacking nutrition knowledge are more prone to adopting coping mechanisms that compromise long-term health when facing shocks—such as drastically increasing the consumption of cheap, high-sugar, and high-fat processed foods, or restricting the intake of certain nutritious foods due to superstitions or taboos—thereby further magnifying the nutrition damage triggered by the shocks (Xu et al., 2020; Muggaga et al., 2017). Conversely, enhanced nutrition awareness enables households to make more nutrition-oriented coping choices during shocks, such as scientifically combining easily accessible local ingredients and adjusting cooking methods to retain nutrients, thus maintaining a relatively balanced dietary structure under resource-constrained conditions (Frankenberger and Nelson, 2023). Thus, nutrition education and knowledge interventions serve not only as public health tools during stable periods but also provide substantial protective functions during shock responses, constituting a proactive capacity-building pathway for establishing individual nutrition resilience.

Fourth, the caregiver's level of nutrition awareness acts as the critical lever for converting household food resources into individual nutrition. At the household level, the effectiveness of nutrition awareness largely depends on the caregiver who is practically responsible for food procurement, storage, and cooking. For female caregivers in charge of household dietary decisions, their level of nutrition knowledge directly determines whether household food resources can be effectively translated into the actual nutrition intake of each member (Ruel and Menon, 2002; Smith et al., 2003). However, economic shocks often exacerbate women's time poverty, subjecting them simultaneously to the dual pressures of income generation and caregiving, which compresses the time and energy available for careful food preparation and consequently weakens the practical effects of converting enhanced awareness into nutrition outcomes (Sabarwal et al., 2011). In rural Chinese families characterized by skip-generation care, reinforcing the modern nutrition knowledge of grandparents is equally paramount: grandparents assuming caregiving responsibilities are often constrained by traditional dietary habits and struggle to meet the specific nutrition demands of children's growth and developmental stages; targeted cognitive interventions can effectively bridge this gap (Chen and Zhao, 2012; Cui et al., 2015). Therefore, prioritizing the inclusion of caregivers—particularly rural women and elderly caregivers—within the coverage of nutrition education is the key to elevating the efficacy of household nutrition awareness interventions.

### 4.3.4 Intra-household Resource Allocation

The aforementioned three dimensions collectively determine the household's ability to acquire and utilize food resources, whereas the intra-household allocation mechanism dictates how food resources are distributed among different members and ultimately influences an individual's ability to maintain adequate nutrition intake. Various types of shocks—whether external economic fluctuations and supply chain disruptions, or internal occurrences like member illness and loss of labor capacity—will trigger or exacerbate allocation biases within the household. Among these, health shocks often trigger dual effects: resources skewing toward the ailing member and the caregiver experiencing time poverty, thereby creating a double squeeze on the nutrition safeguards for vulnerable members. This process is systematically moderated by multiple factors including gender power structures, intergenerational relations, cultural norms, and institutional environments, which collectively determine the decision rules and priority targets of decisions, ultimately impacting an individual's ability to maintain adequate dietary nutrition.

First, the overlay of women's insufficient bargaining power and caregiving burdens constrains the nutrition intake of children and the household as a whole. Women's bargaining power and control over resources within the family directly influence the household's expenditure structure. When women hold greater control over resources, household investments in children's nutrition, health, and education are significantly higher (Duflo, 2003; Jose, 2022; Buhler, 2019). Traditional gender norms primarily assign food preparation and caregiving responsibilities to women (Ruel and Menon, 2002); however, when shocks occur, women must also shoulder the additional time costs of caring for the sick, and this dual compression of income-generating capacity and housework time directly impairs the frequency and quality of infant feeding, as well as the overall household dietary level (Smith et al., 2003; Sabarwal et al., 2011). When resources are tight, the nutrition status of girls may be more susceptible to compromise than that of boys; in certain cultural contexts, boys enjoy distinct priorities in accessing nutrient-rich foods and timely medical care (Kennedy and Peters, 1992; Bradshaw et al., 2015).

Second, generational hierarchies within households can leave children and older adults systematically disadvantaged in food allocation, and the resulting nutrition damage may be irreversible. Vast disparities exist in the status of different age groups regarding intra-household resource allocation, directly affecting "whose needs are met first" and "who bears greater nutrition losses" in shock scenarios. Children are entirely dependent on adults' decisions; during shocks, households might slash investments in children's education and health, or even pull children out of school to work to offset income losses (Peter, 2015; Zhou et al., 2022). Left-behind children frequently confront dual vulnerabilities: while parents migrating for work can augment household income, it struggles to offset the nutrition deficits resulting from caregiving absence; moreover, the limited nutrition awareness of grandparents in skip-generation care setups further undermines children's dietary quality (Chen and Zhao, 2012; Cui et al., 2015). It must be particularly emphasized that for pregnant and breastfeeding women and infants within the first 1,000 days of life—a critical developmental window—if they are disadvantaged in intra-household allocation during a shock, the impaired cognitive development and human capital losses caused by nutrition gaps are often irreversible and will not automatically mend as food intake volumes recover (Alderman et al., 2006; Bhutta et al., 2013). Older adults often engage in self-sacrificing behavior, choosing not to express their nutrition needs when household resources are constrained. Evidence suggests that even when the out-migration of working-age household members increases total household income, improvements in older adults' nutrition status remain limited, as resources are more often directed toward education and housing improvements, while older adults' nutrition needs are neglected (Wang and Lan, 2011).

Third, institutional exclusion diminishes the efficiency of resource-to-nutrition conversion for migrant population households. The hukou system and large-scale population mobility have created a unique urban-rural dual mobility landscape, creating issues such as gaps in social security, residential instability, and dilemmas in child placement, which severely restrict the allocation efficiency of nutrition resources. Although migrant remittance income strengthens the economic buffering capacity of rural households, declines in caregiving quality can offset this advantage. In particular, seasonal labor demands in agriculture can create temporary caregiving gaps in rural households. As women are often responsible for both farm work and family care, busy agricultural seasons intensify their time constraints and reduce the time available for meal preparation, feeding, and care. This, in turn, heightens nutrition risks for vulnerable household members.

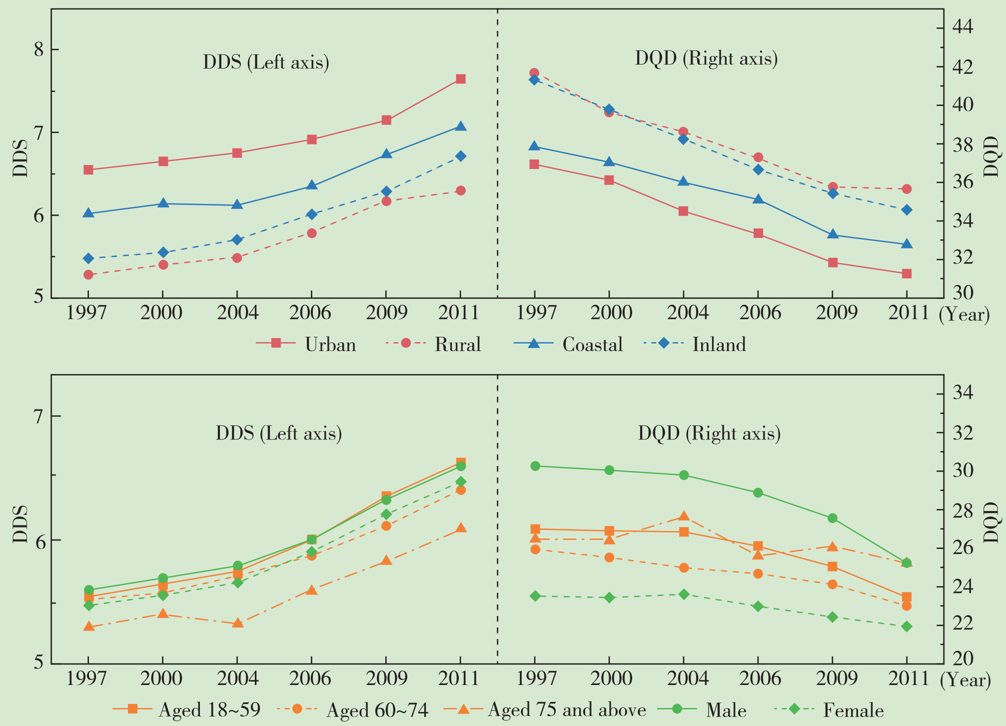
It is worth noting that allocation mechanisms do not solely produce negative effects. Research shows that elderly individuals co-residing with younger family members have significantly higher dietary diversity compared to those living alone (Gao et al., 2026), indicating that intra-household "intergenerational support" and "shared decision-making" exert important positive effects on the nutrition protection of vulnerable members. This suggests that policy designs must not only rectify allocation biases but also actively leverage the positive buffering mechanisms of family networks and community support. Gender norms, intergenerational power dynamics, and institutional exclusion represent the three major structural factors affecting intra-household allocation; this implies that any intervention aimed at enhancing individual nutrition resilience must penetrate the household unit and place vulnerable individuals–such as women, children, and older adults–at the core of targeted guarantees.

### **Box 4.1** Hidden Inequalities Amid the Improvement of Dietary Quality: Differences in Intra-household Resource Allocation in China (1997-2011)

Between 1997 and 2011, the overall dietary quality of Chinese residents exhibited a continuous upward trend; residents' dietary diversity increased, and the overall level of dietary imbalances declined. From an urban-rural perspective (Figure 4-2 top), although the dietary quality of urban residents has long been superior to that of rural residents, the growth rate in rural areas was significantly higher than in urban areas, leading to a converging trend in the urban-rural gap. From a regional perspective (Figure 4-2 top), while the dietary quality of residents in coastal regions was generally higher than that in inland regions, inter-regional gaps gradually narrowed over time, exhibiting a bridging trend in regional disparities.

Furthermore, dietary improvements manifest with distinct heterogeneity across different demographic groups. By age group (Figure 4-2 bottom), adults aged 75 and above have the lowest Dietary Diversity Scores (DDS) while demonstrating relatively high Dietary Quality Distances (DQD)–which reflect levels of dietary imbalance–indicating that their dietary issues appear not only as an insufficiency

**Figure 4-2 Group differences in residents' dietary quality, 1997-2011**

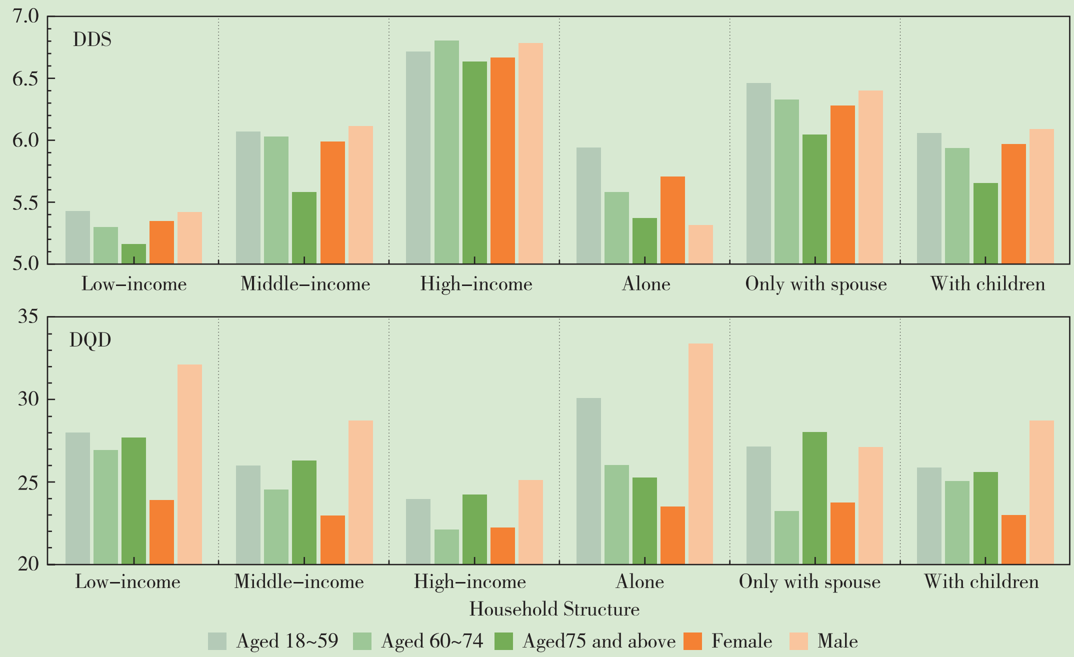



**Data source:** China Health and Nutrition Survey (CHNS), 1997-2011.

of food types but also as dietary imbalances. By gender (Figure 4-2 bottom right), although men's dietary diversity is comparable to that of women, their level of dietary imbalance is significantly higher than that of women, reflecting more severe issues of energy excess or structural imbalances. These discrepancies may reflect differences in the household economic conditions of varying age/gender groups, and they may also correlate with disparities in intra-household resource allocation that yield differing dietary structures among members.

Further analysis reveals that even under equivalent income levels, significant intergenerational and gender differences persist regarding resource allocation within the household (Figure 4-3). In low-income and middle-income families, the DDS of the adults aged 75 and above and that of women are relatively low, demonstrating that under conditions of limited resources, household decisions tend to prioritize safeguarding young and middle-aged laborers. Although this allocation disparity is mitigated in high-income families, it has not disappeared. On the other hand, household structure has a significant moderating effect on allocation. Compared to single-person households, in families co-residing with spouses or family members, gender and age differences among members regarding DDS and DQD converge significantly. This indicates that intra-household "intergenerational support" is critical to the nutrition protection of vulnerable members. Therefore, the focus of dietary intervention policies should not rest solely on macro-level urban-rural or regional dimensions, but must more urgently and precisely identify and concentrate on the vulnerable nodes within the household allocation chain—especially older adults and women in low-income families, as well as members residing in high-risk household structures such as those living alone. These groups constitute the key to elevating the precision and effectiveness of future nutrition intervention policies.

**Figure 4-3 Individual differences in residents' dietary quality across households by incomes and structures**




**Data source:** China Health and Nutrition Survey (CHNS), 1997-2011.

### 4.3.5 Interactions of the 4A Mechanisms

It is worth noting that the above four mechanisms do not operate in isolation but intertwine and synergize to affect individual nutrition resilience. From the perspective of interactive mechanisms, the most typical pattern is the "cascading effect caused by reduced affordability": declines in income or surges in food prices first compress the household's actual food budget, forcing a reduction in food expenditures or a shift toward low-priced, low-nutrition food substitutes; under conditions of insufficient nutrition knowledge, it is difficult for households to achieve effective substitutions among limited food choices; the aforementioned pressures converge upon the intra-household allocation process, where vulnerable members first bear the nutrition losses. This chain manifests most completely in low-income rural households, where the vulnerability of every link amplifies the ultimate nutrition losses.

From the perspective of group heterogeneity, the vulnerability of nutrition resilience is often the result of overlapping multiple mechanisms. Low-income families face the multiple disadvantages of a barren food environment, restricted nutrition knowledge, and unfair intra-household allocation, easily forming a "vulnerability trap". This structure of overlapping multiple vulnerabilities renders it difficult for single-dimension policy interventions to effectively elevate overall nutrition resilience, thus necessitating cross-mechanism, systemic support. Additionally, informal support mechanisms—such as neighborhood mutual aid, family remittance networks, and community meal assistance—also partially constitute positive buffers beyond policy interventions, and their roles will be further discussed in the ensuing sections on policy practices.

From the overall logic of the analytical framework, intra-household allocation acts as the core mediator permeating all four major mechanisms; impaired affordability, reduced accessibility, and insufficient nutrition awareness ultimately rely on intra-household allocation to determine which member shoulders greater nutrition losses. This implies that elevating overall household resources is insufficient to guarantee nutrition security of vulnerable individuals; effective policy interventions must simultaneously operate at the two levels of resource acquisition and internal allocation, placing vulnerable individuals—especially women, children, and the rural elderly—at the center of interventions.

**Box 4.2** Consumer Resilience Responses under External Shocks: Case Studies of the African Swine Fever and Hailstorms Impacts

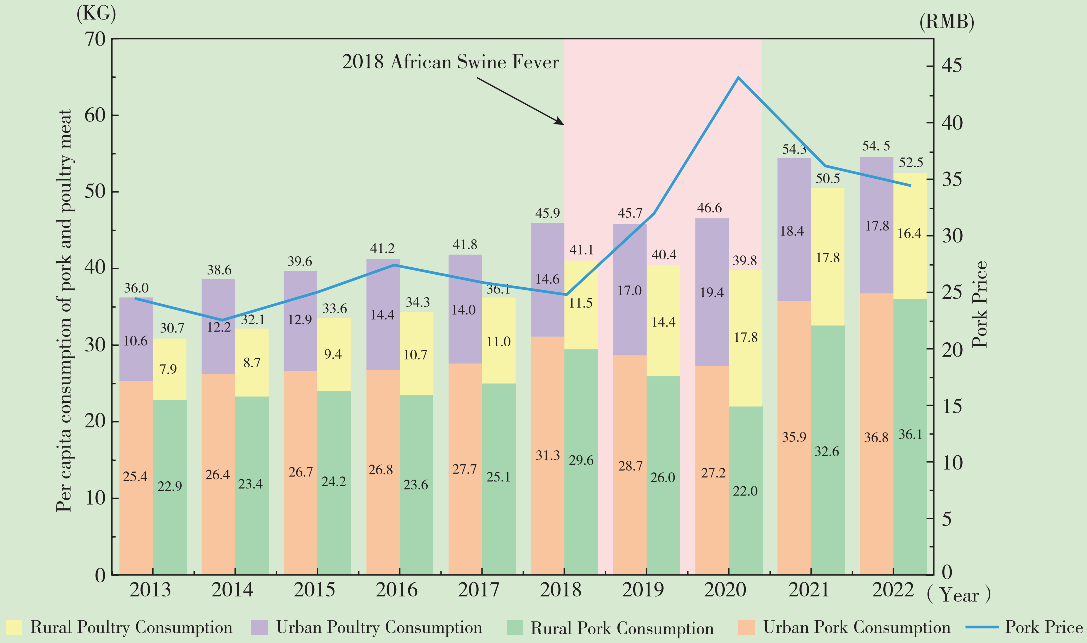
This section, based on per capita consumption data of urban and rural residents and rural market price data nationwide from 2013 to 2022, takes the 2018 African Swine Fever and the 2017 hailstorm disaster as examples to systematically analyze the impact of external shocks on residents' food consumption structures and their recovery trajectories. Taking the 2018 African Swine Fever as an example, the sharp decline in live pig production capacity triggered a surge in pork prices between 2019 and 2020, skyrocketing from approximately 25 RMB per kilogram to a peak of 45 RMB per kilogram (see Figure 4-4). Facing the price shock, urban and rural residents exhibited clear adaptive substitution in consumption. Between 2019 and 2020, the per capita pork consumption of both urban and rural residents showed a significant decline, with urban residents dropping from 31.3 kg prior to the shock in 2018 to 27.2 kg in 2020, and rural residents falling from 29.6 kg to 22.0 kg. Concurrently, the poultry consumption of urban and rural residents increased substantially, playing a critical substitution role, with urban poultry consumption surging to a high of 19.4 kg. Thanks to this proactive adjustment of the consumption structure, the total meat consumption of urban and rural residents did not experience a massive slump during the shock period; under budget constraints, households maintained basic meat consumption needs through the strategy of "reducing pork and increasing poultry," and this substitution is a manifestation of residents' consumption resilience.

In contrast, the impact of the 2017 northern hailstorms on the apple market exhibited typical time-lagged characteristics (see Figure 4-5). Because apples are a storage fruit that can be supplied year-round from inventories, prices did not show abnormal fluctuations immediately in the year of the disaster. Instead, the impact became more visible in the following year as inventories were depleted, with apple prices rising from approximately RMB 9.5 per kilogram to a peak of about RMB 11.5 per kilogram between 2018 and 2019. During the same period, the per capita apple consumption of urban residents experienced a slight decline, while the consumption growth rate of rural residents significantly slowed down and briefly stagnated. Compared to the pork shock, apples possess a higher category substitution elasticity; the government effectively controlled the amplitude of price fluctuations by optimizing the "South-to-North Fruit Transfer" circulation network and increasing the deployment of alternative fresh fruits through the "Vegetable Basket" system. Results show that urban residents' consumption recovered within approximately one year, whereas rural residents' consumption recovered slowly, only converging toward urban levels by 2022.

The aforementioned cases reveal three key insights on consumption resilience: First, supply rigidity determines the persistence of the price effect of shocks; the higher the category substitution elasticity, the faster the consumer side recovers. Second, the "Vegetable Basket" system exhibits significant buffering effects in cross-regional deployment and category adjustment, but its protection of nutrition quality (not merely caloric supply) still requires strengthening. Third, both shocks presented clear urban-rural imbalances: constrained by unsound terminal circulation systems and a scarcity of alternative channels, the recovery cycles of rural residents are generally longer than those of urban residents, a structural vulnerability that requires special attention in policy design.

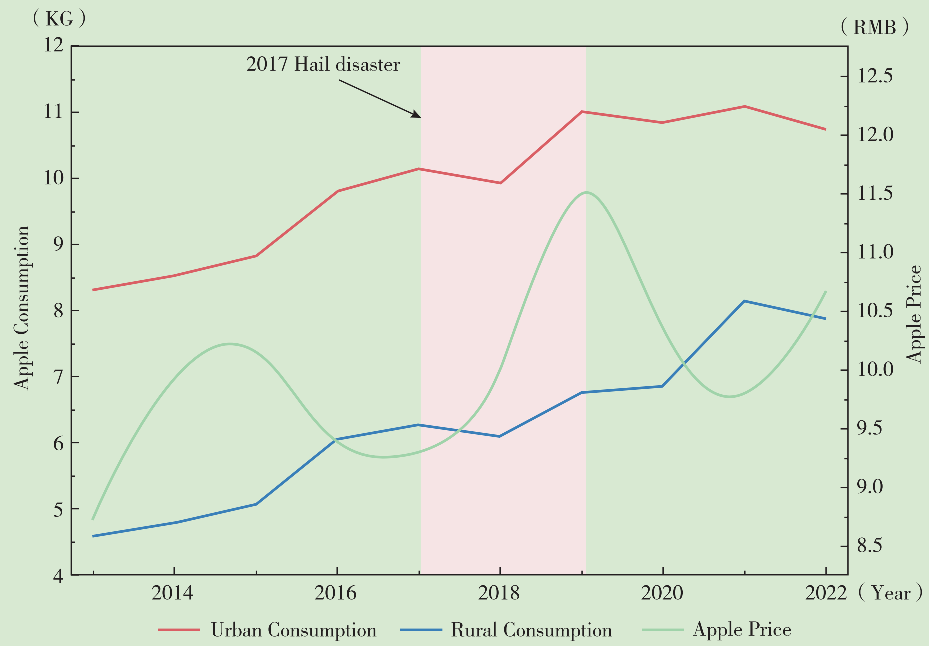
It is worth noting that the "recovery in consumption volume" discussed in the above cases is not equivalent to the elimination of nutrition losses. Taking the African Swine Fever as an example, the full recovery of the pork market took over two years, and this period coincided exactly with the critical window of the "first 1,000 days of life" for many infants and young children. During this stage, insufficient nutrition intake can lead to irreversible developmental stunting and is closely related to impaired cognitive development and long-term human capital losses (Alderman et al., 2006; Bhutta et al., 2013). For pregnant women, insufficient intake of protein and iron during the shock period will directly affect fetal weight and postnatal immune function, and such damage will not automatically repair as market prices return to normal. This implies that relying solely on the "consumer-side recovery cycle" to measure consumer nutrition resilience will systematically underestimate the long-term nutrition consequences of shocks on vulnerable populations. Therefore, the timeliness of policy interventions and emergency responses must match the time windows of critical life periods, rather than merely chasing the rhythm of market recovery.

**Figure 4-4 Trends in pork and poultry consumption and prices for urban and rural residents, 2013-2022**




**Data source:** Per capita food consumption are from the China Statistical Yearbook; agricultural product market price are from the China Rural Statistical Yearbook.

**Figure 4-5 Trends in apple consumption and prices for urban and rural residents, 2013-2022**




**Data source:** Per capita food consumption are from the China Statistical Yearbook; agricultural product market price are from the China Rural Statistical Yearbook.

## 4.4 Policy Pathways to Strengthen Nutrition Resilience

In the face of frequent global shocks and long-term structural challenges within the agrifood system, countries have gradually developed differentiated policy practices centered on the 4A framework. Drawing on a review of typical international experiences, this section systematically evaluates the main achievements and challenges of China's current policy system, with the aim of providing a basis for differentiated intervention pathways.

### 4.4.1 Analytical Framework for Enhancing Nutrition Resilience Pathways

As previously analyzed, nutrition resilience has dynamic characteristics. Therefore, building upon the 4A analytical framework, this study integrates the three process dimensions of "absorption-adaptation-transformation" to construct an analytical matrix (Table 4-1). The following two sections use this matrix to explore pathways for enhancing nutrition resilience from the perspectives of international experience and Chinese practice, respectively.

### 4.4.2 International Experience in Nutrition Resilience Building

Various countries have accumulated differentiated policy practices in enhancing nutrition resilience; their core logic and reference value for China are summarized as follows.

(1) Affordability dimension: the nutrition effect of income support hinge on household resource control rights and conditional constraint mechanisms, rather than the subsidy scale alone.

Countries have gradually formed four types of support models: unconditional cash transfers, conditional cash transfers, restricted-use in-kind benefits, and employment guarantee types. Regarding resource control rights, Brazil's "Bolsa Família" program distributes cash directly to mothers, significantly enhancing children's dietary diversity and micronutrient intake (Escher et al., 2024), proving that financial control rights are the key variable determining the effects of nutrition improvements. In terms of use-restriction designs, the US Supplemental Nutrition Assistance Program (SNAP)

**Table 4-1 Nutrition Resilience Analysis Matrix and Enhancement Pathways Based on the 4A Framework**

| 4A mechanism | Absorptive capacity | Adaptive capacity | Transformative capacity | Typical policy pathways* |
|---|---|---|---|---|
| Affordability | Maintain basic nutrition consumption during shocks | Adjust food budgets and make nutrition-sensitive substitutions | Build more stable capacity to afford nutritious diets | Income support, price subsidies, nutrition vouchers, student nutrition programs, community canteens |
| Accessibility | Maintain basic food access channels during shocks | Shift to alternative channels and diversify sources of supply | Build stable and diversified food supply networks | Food reserves, cold-chain logistics, retail access points, e-commerce delivery, school-based food supply |
| Nutrition awareness | Maintain basic scientific dietary judgment during shocks | Adjust food choices in response to changing constraints | Build stronger capacity for healthy dietary decision-making | Nutrition education, dietary guideline dissemination, food labeling, community health promotion |
| Intra-household food allocation | Protect the basic nutrition needs of key vulnerable members | Improve intra-household resource allocation | Build a fairer and more nutrition-sensitive allocation mechanism | Child nutrition interventions, school and childcare meals, nutrition support for pregnant and breastfeeding women and older adults, family nutrition guidance |

**Note:** Specific international and Chinese practice within the typical enhancement pathways are detailed in Appendix 4-1.
**Source:** Compiled by the authors.

utilizes category-restricted electronic food vouchers to ensure transfer payments are exclusively used for food consumption, and its effectiveness in improving the dietary quality of low-income families has been widely validated. Regarding condition settings, Mexico's "Oportunidades" program links cash assistance to children's school enrollment rates, vaccination, and health check-ups, achieving dual goals of poverty reduction and human capital accumulation. This bundled model of "conditional transfers + nutrition services" is an effective pathway for converting income support into substantive nutrition improvements and holds direct reference value for the precise design of China's social assistance system. The aforementioned international practices indicate that at the absorption level, price subsidies and cash transfers can quickly buffer the impact of shocks on purchasing power; at the adaptation level, tools like conditional transfers and nutrition vouchers can guide households to adjust toward nutrient-dense consumption structures; at the transformation level, embedding a nutrition-sensitive design into the design of social security systems is a long-term pathway to establishing more stable capacity to afford nutritious diets.

Cash-transfer, food-voucher, and in-kind assistance programs can directly improve the ability of vulnerable groups to pay for nutritious foods. For example, the US Supplemental Nutrition Assistance Program (SNAP) improves low-income households' food purchasing power through food vouchers and effectively mitigates nutrition insecurity caused by income shocks. The Women, Infants, and Children (WIC) program further combines food vouchers with nutrition education, targeting pregnant women, infants, and young children in critical life windows. The implication for China is that social assistance should shift from cash-based baseline protection toward nutrition-sensitive protection, particularly by improving the nutrition orientation and individual targeting of assistance during shocks.

(2) Accessibility dimension: effective interventions should ensure both stable food supply and access for those in need, while strengthening rapid coordination mechanisms during crises.

In terms of stabilizing supply, countries have universally established food reserve systems to stabilize price fluctuations and ensure emergency supplies; the local and regional procurement policies promoted by the World Food Programme enhance the food system's capacity to withstand external shocks by "prioritizing local food procurement," which significantly fosters the development of short-chain supply systems. In terms of improving supply chain risk response, forward-looking research and risk early-warning mechanisms also provide scientific support for food system governance. For instance, Japan conducts forward-looking research every five years to predict social trends over the next 20 to 30 years to guide policy adjustments in the food system. Regarding optimizing the food environment, practices in countries like Brazil, Ghana, and the US demonstrate that school meal programs concurrently serve the triple functions of nutrition intervention, educational incentive, and social protection; Cambodia and the Bahamas maintained supply chain continuity by converting school meals into household food packages during the pandemic. In terms of crisis response, food banks buffer market fluctuations by mobilizing volunteer networks and adjusting distribution models; for example, regional food projects in France accurately guaranteed food accessibility for vulnerable groups during the pandemic through "solidarity food baskets" (Aida et al., 2023). The core takeaway for China lies in the necessity to simultaneously build supply chain stabilization mechanisms and terminal distribution systems to avoid the systemic blind spot of "having reserves but no delivery channels." At the absorption level, grain reserves and cross-regional deployment mechanisms can quickly fill supply gaps; at the adaptation level, emerging distribution channels like e-commerce and community group buying provide diversified acquisition alternatives; at the transformation level, perfecting cold chain infrastructure and building short-chain supply systems are fundamental to enhancing the long-term resilience of the food system.

(3) Nutrition awareness dimension: interventions can be sustained only if they move beyond short-term projects and become institutionalized services, with nutrition education closely coordinated with material support.

Knowledge dissemination alone is unlikely to induce behavioral change. Instead, effective interventions require the coordinated design of cognitive enhancement and resource-access support. The US WIC program and the UK's "Healthy Start" program bundle food voucher support with nutrition education, providing food vouchers and nutrition education during critical windows for pregnant women and young children, thereby effectively enhancing the intervention's efficacy. Ghana transferred its girls' iron and folic acid supplementation program to the routine operation of the health system, achieving a sustainable transition from a temporary project-based scheme to normalized services. Australia incorporated the principle of equity into the formulation of its dietary guidelines, explicitly focusing on the affordability for low-income groups, making nutrition knowledge dissemination not just a cognitive exercise but practically feasible. The implication for China is that if nutrition education is divorced from the practical constraints of resource conditions, it will be difficult to translate into substantive dietary improvements; the synergistic design of knowledge interventions with affordability and accessibility is key to enhancing intervention efficacy. At the absorption level, real-time dietary guidance from grassroots health institutions can help households maintain basic scientific dietary judgments during shocks; at the adaptation level, incorporating nutrition education into the public health service system can promote the systematization of knowledge dissemination; at the transformation level, systematic capacity building targeting caregivers and the institutional transition of cognitive interventions are long-term mechanisms for forming stronger healthy dietary decision-making capabilities.

(4) Intra-household food allocation dimension: targeting vulnerable individuals rather than the household as a whole as the central target of resource allocation is an international consensus for enhancing the effects of nutrition policies.

The precise expansion of the social protection system during crises has become a key means of safeguarding livelihoods; for instance, during the COVID-19 pandemic, India and South Africa extended social assistance to the unemployed, women, and children, reflecting the rapid response capability of their social protection systems (Gronbach et al., 2022). In terms of targeted fiscal and financial support, it primarily involves empowering food production and business entities. For example, Ethiopia and Nigeria provided low-interest loans to micro, small, and medium-sized enterprises (MSMEs) in the food sector, stabilizing grassroots food supply chains and employment (Quak et al., 2022); Ethiopia further optimized policies by covering operational costs through soft loans and relaxing registration restrictions to emphatically support informal enterprises run by women (Quak et al., 2022). In resource allocation, cross-departmental synergy significantly boosts efficiency; for instance, Peru ensured the efficient matching of the rice supply chain from field production to terminal sales through inter-departmental linkages (Giner et al., 2022). In contrast, related decision-making in China is currently still highly administrative (Cai et al., 2022), and urgently requires the introduction of multi-stakeholder participation. Concurrently, making vulnerable groups such as women and low-income individuals the core orientation of resource allocation to prevent allocation imbalances and guarantee the inclusivity of nutrition resilience has become a core international consensus for enhancing policy efficacy (Placzek, 2021).

### 4.4.3 China's Policy Achievements and Main Challenges in Enhancing Nutrition Resilience

China's current policy system has established a multi-tiered protection framework, anchored in the social protection system, supported by food security strategies, and supplemented by targeted nutrition interventions. Practical responses to major emergencies, such as the COVID-19 pandemic, have also tested and strengthened the system's capacity for coordinated response. The following section reviews the achievements and limitations of this policy system along the four dimensions of the 4A transmission framework.

(1) In the affordability dimension, the absorptive capacity of current policies has taken initial shape, but the nutrition-oriented design for adaptive adjustment and transformative upgrading remains underdeveloped.

In terms of emergency support, China has established a price subsidy linkage mechanism dynamically linked to the Consumer Price Index (CPI), ensuring that subsidy standards timely track price fluctuations, thereby effectively offsetting the impact of price volatility on the actual purchasing power of low-income groups. During the COVID-19 pandemic in 2020, cumulative temporary price subsidies amounting to 19.09 billion RMB were issued throughout the year, benefiting 310 million beneficiary instances. Concurrently, complemented by the expansion of the minimum living allowance ("dibao") and temporary assistance policies, it effectively bridged the gaps caused by unemployment or income interruption, playing a crucial policy safety net function. The dynamic adjustment mechanism of "precise policy implementation" and the food supply guarantee effects during the pandemic reflected the rapid response capability of China's social security system under major shocks. However, current affordability guarantee mechanisms still possess obvious limitations regarding the efficiency of nutrition conversion. First, A cash-transfer-centered assistance system lacks a clear nutrition orientation and has limited capacity to guide low-income families toward more nutrient-dense food choices. Second, current subsidy standards primarily reference calories and basic living costs, giving insufficient consideration to safeguarding dietary diversity and micronutrient intake. Third, institutional designs based on the household unit are difficult to effectively reach vulnerable individuals within the household; whether the subsidies can translate into actual nutrition intake improvements for members such as women, children, and older adults remains highly dependent on the fairness of the intra-household allocation mechanism.

**(2) In the accessibility dimension, the emergency response mechanisms supporting absorptive and adaptive capacity are relatively complete, but the transformative infrastructure shortcomings have not been systematically resolved.**

In terms of stabilizing supply, by the end of 2022, China had established a grain emergency guarantee network covering urban and rural areas, with an emergency processing capacity sufficient to meet the nation's basic grain and oil needs for approximately two days. Meanwhile, the "Four Simultaneous Emphases" ("四个并重") supply guarantee framework organically combines macroeconomic regulation with market mechanisms, effectively preventing supply distortions and building a solid foundation for food security. The "Vegetable Basket" Mayor Responsibility System, by clarifying the main responsibilities of local governments, has promoted the optimization of the layout of major agricultural production bases and cross-regional deployments, playing a sustained role in stabilizing the supply of fresh agricultural products such as vegetables and meat. In terms of responding to sudden shocks, the "government-market-society" collaborative governance model has rapidly matured, significantly enhancing supply chain resilience. For instance, during the COVID-19 pandemic, community group buying significantly reduced circulation costs through a "presale + self-pickup + next-day delivery" mechanism, while e-commerce platforms utilized technological innovations like contactless delivery and intelligent scheduling to reduce contact risks while enhancing supply chain operational efficiency during special periods (Luo et al., 2020; Liang and Zhong, 2022; Liu et al., 2024), playing a key role in ensuring food acquisition. However, the current accessibility guarantee system exhibits obvious urban-rural and regional imbalances regarding terminal accessibility. On one hand, the dietary diversity level of children in remote western regions shows a significant gap compared to urban areas; weak cold chain infrastructure is a critical bottleneck restricting the local accessibility of nutrient-dense foods, and current policies have yet to form a systematic solution to this. On the other hand, the expansion of digitized circulation channels has exacerbated the acquisition barriers for vulnerable groups such as the rural elderly, and the structural issue of the existing reserve system being centered on staple grains with insufficient emergency guarantee capacity for nutrient-dense foods also remains to be resolved.

**(3) In the nutrition awareness dimension, China has already established a nationwide nutrition education and knowledge dissemination system, with grassroots services for short-term shock absorption fully rolled out; however, systematic interventions at the adaptation and transformation, capacities as well as the coverage of targeted populations, still exhibit clear deficiencies.**

China has incorporated nutrition education into its public health policy framework. The National Nutrition Plan calls for integrating nutrition education into the basic public health service system, while the Chinese Dietary Guidelines are regularly revised and published to provide science-based dietary guidance for the public. In some regions, food and nutrition education has been included in school health education during compulsory education. At the community level, primary healthcare institutions have also begun to provide personalized dietary guidance through family doctor contract services, particularly as part of chronic disease management. Together, these efforts have created a multi-level framework for nutrition knowledge interventions, linking guideline development, public education, and community-level implementation. However, important gaps remain. First, nutrition education often emphasizes ideal dietary patterns without fully considering the purchasing-power constraints faced by low-income households, making it difficult for knowledge to translate into actual dietary improvements. Second, key actors in household food decision-making—including rural female caregivers, grandparents in skip-generation caregiving households, and older adults living alone—remain insufficiently covered by targeted nutrition education. Third, existing nutrition education channels rely heavily on new media platforms, limiting their effectiveness for rural older adults with restricted digital access or low digital literacy.

**(4) In the dimension of intra-household food allocation, targeted interventions have begun to move beyond the household-level targeting to reach vulnerable individuals more directly. Initial mechanisms have been established to support key groups' shock absorption and adaptive capacity. However, these interventions lack mature institutionalization and suffer from inadequate population coverage.**

China has established specialized nutrition intervention systems targeting three key groups: children, infants and young children, and pregnant and breastfeeding women, to some extent achieving targeted guarantees for vulnerable members within the household. For example, the Rural Compulsory Education Student Nutrition Improvement Program has improved the dietary quality of rural students by directly providing nutritious meals to them, and empirical research demonstrates its significant positive impact on nutrition status and school retention rates (Ma et al., 2025); the Child Nutrition Improvement Project in poverty-affected areas has effectively improved the early developmental level of infants and young children through the distribution of nutrition packages (Yang et al., 2019); pregnant and breastfeeding women's nutrition interventions rely on the maternal and child health care network to provide targeted nutrition support, covering the core nutrition needs during critical life windows. Regarding the safeguarding of elderly groups, meal assistance services represented by Zhejiang's elderly meal assistance provide a localized sample for translating intra-household allocation policy interventions into sustainable institutional arrangements (see Box 4-3), proving the feasibility and effectiveness of interventions targeting specific groups. However, current policies still face challenges. First, there are obvious institutional coverage blind spots for new vulnerable groups such as the rural left-behind elderly and the accompanying children of the urban migrant population. Second, policy designs based on the household unit struggle to effectively identify and correct intra-household gender and intergenerational allocation inequalities. Third, some existing intervention programs face a gap between program availability and implementation quality. At the same time, cross-departmental data sharing remains inadequate, timely micro-level data on consumption and food prices are difficult to obtain, and dynamic nutrition monitoring at the individual level is still lacking. These constraints substantially weaken the capacity of policy interventions to accurately identify nutritionally vulnerable individuals within households.

China's current policy system therefore needs structural transformation in three respects. First, it must shift from guaranteeing basic subsistence to protecting nutrition quality. Existing systems remain insufficient in guiding food consumption toward nutrient-dense foods and in safeguarding dietary quality, rather than merely ensuring adequate caloric intake. The current reserve system still relies heavily on staple grains, leaving emergency support for nutrient-dense foods relatively weak. In some areas, the phenomenon such as "meals without adequate nutrition" persists, while accessibility gaps in central and western rural areas have not yet been systematically addressed. Second, policy targeting needs to shift from households as a whole to nutritionally vulnerable individuals within households. Household-based policy designs often fail to reach vulnerable family members directly. Emerging vulnerable groups—including urban sandwich-generation households facing both caregiving and economic pressures, migrant populations, left-behind children, and older adults living alone—continue to fall through important gaps in policy coverage. Third, the policy approach needs to shift from reactive emergency response to proactive risk prevention. Current interventions still focus mainly on ex post responses. Cross-departmental data sharing, high-frequency data collection, and dynamic early-warning mechanisms remain underdeveloped, making it difficult to identify risks and trigger targeted interventions before

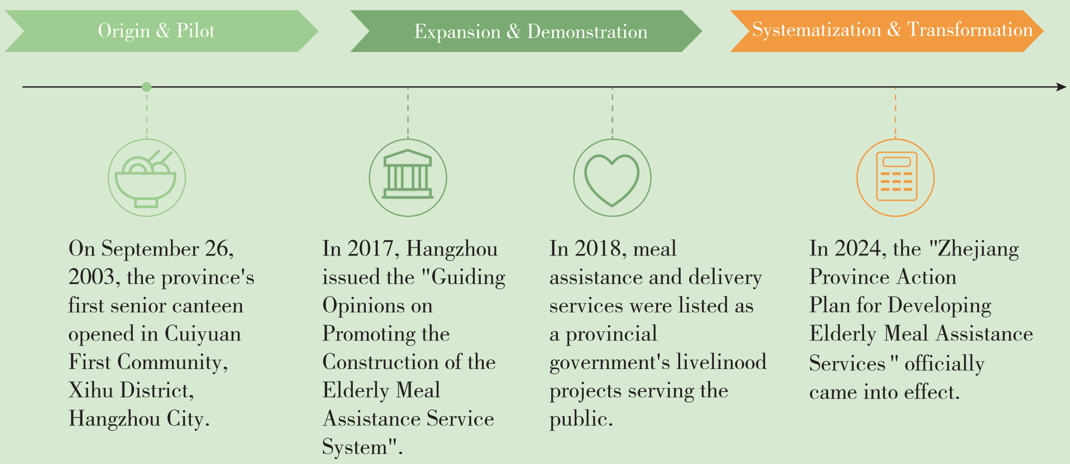
## Box 4.3 From Catering Services to Nutrition Resilience Infrastructure: Practices and Insights from Elderly Canteens in Zhejiang

Zhejiang's elderly meal assistance services provide an institutionalized solution of how to move beyond the dilemma of relying solely on intra-household allocation for nutrition support (Figure 4-6). After more than two decades of experience, Zhejiang has constructed an elderly meal assistance system characterized by "government guidance, market operation, and social participation"; in 2024, the province had 11,700 elderly meal assistance sites, and an urban-rural coverage network had essentially taken shape. Its main experience lies in adhering to a people-centered approach, highlighting a public-welfare orientation, constructing an "inclusive + basic guarantee" system, and using digital empowerment and model iteration to promote the upgrading of meal assistance services toward integrated health and eldercare.

Despite this, the Zhejiang practice still faces challenges for long-term sustainability. Issues remain prominent, such as imbalanced regional development, high operational costs in rural and remote areas, strong reliance on fiscal subsidies by some canteens, insufficient professionalization of nutrition services, and evaluation systems that rely heavily on quantitative indicators while lacking focus on dietary quality and nutrition outcomes.

Overall, enhancing the nutrition resilience of older adults cannot rely solely on the spontaneous adjustment of intra-household allocation, but requires incorporating meal assistance services into the normalized basic public service system, using institutionalized supply to compensate for the structural degradation of family caregiving functions. This pathway is equally applicable to the nutrition-sensitive social protection design for other vulnerable individual groups.

**Figure 4-6 Development of elderly canteens in Zhejiang Province**




**Source:** Xinhua News Agency, Zhejiang Provincial Department of Civil Affairs.

shocks occur. As a result, proactive protection remains inadequate, especially for vulnerable groups in critical life windows.

# 4.5 Conclusions and Policy Recommendations

## 4.5.1 Conclusions

This chapter, centered on the core concept of "consumer-side nutrition resilience," constructs a systematic analytical framework from theory to policy pathways, and yields the following five core findings.

First, guaranteeing individual nutrition security requires attention to the intra-household allocation mechanism. Existing research and policies generally measure nutrition resilience at the household level, which implies the assumption of equal resource distribution within the household. However, intra-household allocation is systematically affected by gender norms, intergenerational power relations, and cultural customs, and therefore often deviates from equal or need-based distribution. This means that even when overall household resources are sufficient, the nutrition security of vulnerable groups such as women, children, and older adults within the household may still not be guaranteed. Incorporating the intra-household allocation mechanism into the analytical framework is this study's core theoretical contribution to nutrition resilience research, and it directly points to the need for a policy transition: interventions must penetrate the household unit and precisely target vulnerable individuals.

Second, shocks are transmitted through four pathways—affordability, accessibility, nutrition awareness, and household allocation—forming mutually overlapping cascading effects. Declining incomes and rising food prices erode purchasing power; disease shocks doubly compress food budgets through the crowding-out effect of medical expenditures and the loss of labor income; supply chain disruptions and deteriorated food environments restrict accessibility; and insufficient nutrition awareness amplifies decision-making losses under resource constraints. The different pathways reinforce each other, exerting the greatest impact on low-income rural households. This finding helps explain why single-dimensional policy interventions often fail to disrupt the transmission of nutrition risk or improve the nutrition status of the most vulnerable groups.

Third, nutrition losses during critical life windows can be irreversible: restored supply does not mean restored nutrition. For pregnant and breastfeeding women, infants, and young children—especially during the first 1,000 days from conception to age two—nutrition gaps caused by shocks can lead to lasting damage to cognitive development, health, and human capital formation. Such losses are not automatically reversed when market supply recovers. If shock impacts are assessed only by the recovery of consumption volume, the long-term consequences for these groups will be systematically underestimated. Policy interventions must therefore respond within the relevant developmental windows, rather than simply follow the pace of market recovery.

Fourth, nutrition vulnerability is highly concentrated in specific groups and regions; precise identification and intervention are prerequisites for enhancing policy efficacy. Low-income households, left-behind children, older adults living alone, pregnant and breastfeeding women, and migrant families often simultaneously face multiple compounding disadvantages, including weak purchasing power, poor food environments, restricted nutrition knowledge, and unfavorable intra-household allocation. Rural areas in the central and western regions and regions with limited industrial diversification exhibit relatively low overall resilience because of vulnerable food environments, imperfect social support networks, and limited emergency response capabilities. This heterogeneity indicates that policy interventions must shift from broad-brush approaches to precise identification and differentiated support.

Fifth, China already has the institutional foundation for a baseline guarantee; achieving a systematic upgrade in nutrition resilience requires triple policy transitions. Current policies have accumulated significant advantages in grain reserves, social assistance, and emergency mobilization, but their design logic remains household-centric, emergency-oriented, and staple-grain-focused, which presents a structural gap compared to the goal of "ensuring that everyone has a stable and nutritious dietary source at all times." Bridging this gap requires triple transitions: transitioning from "guaranteeing basics" to "guaranteeing nutrition," enhancing the nutrition-sensitivity of social security; transitioning from the "family unit" to "vulnerable individuals," establishing precise intervention mechanisms that penetrate the household; and transitioning from "emergency response" to "proactive prevention," incorporating nutrition resilience assessment and monitoring into the existing governance system and systematically integrating it with the Healthy China strategy.

### 4.5.2 Policy Recommendations

Based on the preceding findings, this chapter uses the three-tiered capacity-building framework of absorption-adaptation-transformation to propose the following policy recommendations, with the aim of promoting the structural upgrading of China's nutrition resilience system.

(1) Construct a nutrition-sensitive social security and emergency reserve system to enhance shock absorption capacity.

In response to core challenges such as insufficient coverage of existing social protection mechanisms, the difficulty of reaching vulnerable individuals through household-centered institutional designs, and the limited nutrition-sensitive design of emergency food reserves, China should upgrade both its social security mechanisms and emergency response systems. First, promote a nutrition-sensitive social security transformation. Pilot targeted food voucher systems that restrict a portion of assistance funds to nutrient-dense foods such as fresh fruits, vegetables, dairy products, and soy products, guiding minimum-living-guarantee ("Dibao") households toward high-nutrient-density consumption. In terms of distribution, prioritize the allocation of social assistance funds to primary female caregivers within households, thereby increasing the likelihood that resources are converted into child nutrition. In terms of coverage, include migrant populations and informal workers in the emergency assistance system, breaking through hukou restrictions so that they can receive timely support where shocks occur. Second, establish a nutrition-oriented flexible reserve mechanism. Establish a three-tier food reserve mechanism that coordinates household, community, and government reserves, and upgrade the reserve system from a staple-grain focus to comprehensive nutrition-oriented reserves. For groups in critical life windows, including pregnant and breastfeeding women, infants, and young children, develop rapid-response mechanisms for deploying specialized nutrition packages and issuing targeted nutrition guidance during shocks, so as to prevent short-term disruptions from causing irreversible nutrition-related harm.

(2) Optimize the food environment and inclusive nutrition education to enhance the system's adaptive capacity to shocks.

In response to challenges such as the limited nutrition-sensitive design of food environments, unresolved accessibility gaps in central and western rural areas, and uneven nutrition awareness among residents, policy should act in a coordinated way on the supply side, the cognitive side, and the channel side. On the supply side, put the Big Food Concept into practice and promote diversified agricultural production. Extend policy support beyond staple-grain yields to nutritious crops such as non-staple grains, fruits, and vegetables, and promote biofortified crop varieties in poverty-affected areas. Encourage households to develop household courtyard production as a nutrition buffer when markets are disrupted. On the cognitive side, incorporate dietary and nutrition knowledge into the public health education system. Develop differentiated communication formats for different populations: food education courses for children; personalized dietary guidance for older adults integrated with chronic disease management; and nutrition outreach for residents in remote rural areas through village broadcasts, village clinics, and other accessible channels. For women responsible for household food procurement and cooking, strengthen nutrition decision-making capacity through skills training, while also promoting gender and intergenerational equality in intra-household food allocation. On the channel side, policy should improve both supply accessibility and digital access. For supply accessibility, develop short-chain circulation models such as urban agriculture, direct farmer supply, and community-supported agriculture to improve local access to fresh foods and stabilize prices. For digital access, although digital platforms can connect smallholder farmers with larger markets, rural older adults often cannot benefit from online fresh food delivery and nutrition information services because of limited smart-device skills, weak network coverage, and low trust. To bridge the digital divide, non-digital acquisition channels, such as physical community outlets, mobile vegetable carts, and village clinics, should be retained and strengthened while digital channels are promoted, ensuring that digital transformation does not undermine vulnerable groups' food access.

(3) Break down structural institutional barriers to enhance transformative capacity toward nutrition resilience.

In response to deep-seated challenges such as lack of cross-departmental coordination, the absence of dynamic monitoring mechanisms, and the difficulty of addressing structural vulnerabilities through any single policy, coordination should be strengthened at three levels: institutions, governance, and health integration. First, block the intergenerational transmission of malnutrition. Extend child nutrition improvement programs from compulsory education to the preschool stage, with a focus on addressing quality issues such as "providing meals but lacking nutrition" in schools with high concentrations of left-behind children; establish institutional safeguards for gender and intergenerational equality, including legal and institutional protection of rural women's land rights and credit access; and incorporate meal assistance services into the normalized basic public service system, using institutionalized supply to compensate for the structural weakening of family caregiving functions.

Second, establish cross-departmental collaborative governance and dynamic monitoring mechanisms. Integrate nutrition resilience goals into policy formulation across agriculture, health, education, urban planning, and other sectors; for example, add nutrition-linked clauses to agricultural subsidy policies and increase the density of community canteens and affordable vegetable shops in urban planning. Break down data silos among health, agriculture, civil affairs, statistics, and other departments to build a comprehensive monitoring and evaluation system for household nutrition and resilience, regularly identifying vulnerable groups and high-risk regions to support precise policy iteration. Establish rapid-response contingency plans for high-frequency shocks such as extreme weather, public health events, and abnormal grain price fluctuations, shifting the focus of intervention from ex post response to proactive prevention.

Third, incorporate nutrition resilience building into disease prevention and control systems and the Healthy China framework. Adequate nutrition intake is the material foundation for immune function and chronic disease prevention, while disease shocks in turn are important triggers affecting household and individual nutrition resilience. Individual nutrition assessments should be incorporated into contracted family doctor services to promote synergy between nutrition interventions and chronic disease management; nutrition resilience indicators should also be included in the Healthy China Action monitoring framework to provide sustained empirical support for policy optimization.

### 4.5.3 Research Outlook

This study has the following limitations, which point to directions for future research.

First, access to high-frequency and real-time dietary data remains constrained. Existing research mostly relies on cross-sectional survey data or low-frequency longitudinal data, which cannot adequately capture high-frequency dynamic changes in household dietary and nutrition status when shocks occur. Future research needs to develop high-frequency individual-level dietary data collection systems, integrating 24-hour dietary recalls with digital assistive tools such as photo logging and AI-based nutrition recognition to enable real-time monitoring of nutrition resilience.

Second, causal inference faces endogeneity challenges. The randomness of shocks is intertwined with the endogeneity of household coping strategies, making it difficult to precisely identify causal mechanisms. Future research can use methods such as natural experiments and randomized controlled trials to strengthen the credibility of causal inference and clarify the net effects of different shock types on nutrition resilience.

Third, research on the micro-level mechanisms of intra-household allocation remains insufficient. Existing literature is mostly based on household-level data, with limited empirical evidence on intra-household gender and intergenerational allocation. Future research should develop individual-level nutrition intake survey tools to reveal the heterogeneity of allocation mechanisms and their determining role in the nutrition outcomes of vulnerable members.

Fourth, long-term tracking evaluations of policy effects are largely absent. Current evaluations of nutrition intervention policies mostly focus on short-term effects, with insufficient tracking research on their long-term impacts on health and human capital. In the future, a long-cycle evaluation system for policy implementation should be established to provide scientific support for policy optimization.

In conclusion, safeguarding nutrition security and resilience building represents a systematic undertaking that requires the coordinated efforts of government, market entities, and civil society. Effective policy design must focus down to the household level and place vulnerable groups at the center.

**References**

Aida, E., Mohana, R., Amir, J. A., et al. (2023). Food bank operations: Review of operation research methods and challenges during COVID-19. BMC Public Health, 23(1), 1783.

Akter, S., & Basher, S. A. (2014). The impacts of food price and income shocks on household food security and economic well-being: Evidence from rural Bangladesh. Global Environmental Change, 25(1), 150-162.

Alderman, H., Hoddinott, J., & Kinsey, W. (2006). Long-

term consequences of early childhood malnutrition. Oxford Economic Papers, 58(3), 450-474.
Bailey, M., Bush, S. R., Miller, A., et al. (2019). The role of corporate social responsibility in creating a resilient food system. Food Security, 11(1), 237-247.
Bhutta, Z. A., Das, J. K., et al. (2013). Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? The Lancet, 382(9890), 452-477.
Bradshaw, S., Linneker, B., & Overton, L. (2015). Gender and resilience. London: International Institute for Environment and Development (IIED).
Buhler, D., et al. (2019). The role of female bargaining power in child nutrition: Evidence from Ethiopia. Food Policy, 83, 13-25.
Cai, Y., et al. (2022). Challenges and opportunities for China's food security under the goal of carbon neutrality. Journal of Cleaner Production, 376, 134262.
Campbell, R. K., Talukder, A., Bhattacharjee, L., et al. (2013). Assessing the impact of homestead food production on ethno-linguistic communities in Bangladesh. Food and Nutrition Bulletin, 34(3), 332-344.
Chimeli, J. S., & Shogren, J. F. (2015). Environmental goods and the cost of consumption: A theoretical analysis of nutrition and health. Journal of Health Economics, 41, 124-133.
Di Stefano, V., et al. (2022). Food security and nutrition resilience in fragile contexts: A systematic review. Global Food Security, 32, 100612.
Diansari, P. (2014). Household food and nutrition security: A case study of rural areas in Indonesia [Doctoral dissertation]. Newcastle: Newcastle University.
Duflo, E. (2003). Grandmothers and granddaughters: Old-age pensions and intrahousehold allocation in South Africa. The World Bank Economic Review, 17(1), 1-25.
Escher, N. A., Andrade, G. C., & Ghosh-Jerath, C. S. P. (2024). The effect of nutrition-specific and nutrition-sensitive interventions on the double burden of malnutrition in low-income and middle-income countries: A systematic review. Lancet Global Health, 12(3), e419-e432.
Fan, S., Pandya-Lorch, R., & Yosef, S. (2014). Resilience for food and nutrition security. Washington, DC: International Food Policy Research Institute (IFPRI).
FAO. (2016). Influencing food environments for healthy diets. Rome: FAO.
FAO, IFAD, UNICEF, WFP, & WHO. (2023). The state of food security and nutrition in the world 2023: Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum. Rome: FAO.
FAO. (2014). Nutrition and resilience: Strengthening the links between resilience and nutrition in food and agriculture. Rome: FAO.
FAO. (2016). The state of food and agriculture 2016: Climate change, agriculture and food security. Rome: FAO.
Frankenberger, T. R., & Nelson, S. (2023). Resilience and food security: The evolution of a concept. In Resilience and Food Security. London: Routledge.
Gao, Y., Zheng, Z., & Li, N. (2026). Is intra-household nutrition allocation equitable? Evidence from asymmetric expenditure responses in rural China. Journal of Integrative Agriculture.
Giannopoulos, G., & Naouma, K. (2019). Household coping strategies during the Greek economic crisis: The role of assets and social capital. Journal of Economic Issues, 53(3), 762-784.
Giner, C., & Placzek, O. (2022). Food insecurity and food assistance programmes across OECD countries: Overcoming evidence gaps. OECD Food, Agriculture and Fisheries Papers, No. 183. Paris: OECD Publishing.
Goudge, J., & Govender, V. (2007). A review of health-seeking behaviour and the cost of illness. London: REACH (Researching Equity in Access to Health Care).
Gronbach, L., Seekings, J., & Megannon, V. (2022). Social protection in the COVID-19 pandemic: Lessons from South Africa. Washington DC: Center for Global Development.
Haddad, L., Hoddinott, J., & Alderman, H. (1996). Intrahousehold resource allocation: An overview. Washington, DC: International Food Policy Research Institute (IFPRI).
Headey, D. D., & Ruel, M. T. (2022). Economic shocks and child consumption: Evidence from a global panel of countries. World Development, 153, 105820.
Hendriks, S. L. (2015). The help and hindrance of food security indicators in guiding policy. Food Policy, 51, 115-123.
Herforth, A., & Ahmed, S. (2015). The food environment curriculum: A guide for nutrition professionals and practitioners. Rome: FAO.
Hinks, T., & Leckie, G. (2017). Protecting calorie intakes against income shocks. Bristol Economics Discussion Papers 17/684. Bristol: School of Economics, University of Bristol.
IFPRI. (2020). 2020 Global food policy report: Building inclusive food systems. Washington, DC: International Food Policy Research Institute.
Jose, G. (2022). Women's bargaining power and child nutrition: Evidence from rural India. World Development, 151, 105763.
Kennedy, E., & Peters, P. (1992). Household food security and child nutrition: The interaction of income and

gender of household head. World Development, 20(8), 1077-1085.
Liang, Y., & Zhong, T. (2022). Urban food security and community group buying during the COVID-19 pandemic in China. Land, 11(10), 1851.
Liu, W., Du, H., & Sun, C. (2024). Online community group food purchasing during the COVID-19 pandemic: Food security, problems, and sustainability. Heliyon, 10(8), e29581.
Luo, C., Wu, L., & Liu, N. (2020). Study based on contactless distribution patterns under the outbreak. IOP Conference Series: Earth and Environmental Science, 526(1), 012204.
Ma, Z., Ma, Y., Zou, W., et al. (2025). Free school meals and educational outcomes: Evidence from China's Nutrition Improvement Program. Frontiers in Public Health, 13, 1542861.
Merchant, E. V., et al. (2022). The influence of food environments on food security resilience during the COVID-19 pandemic: An examination of urban and rural difference in Kenya. Nutrients, 14(14), 2939.
Montalbano, P., & Romano, D. (2023). Is food security a matter of resilience? Evidence from Ethiopia. World Development, 161, 106114.
Muggaga, C., et al. (2017). Nutrition knowledge, attitudes and practices among households in food-insecure contexts. Journal of Nutrition Education and Behavior, 49(7), S45.
Muricho, G., Otieno, D. J., & Oluoch-Kosura, W. (2018). Analysis of household food security resilience in the face of shocks in Kenya. Food Security, 10(6), 1561-1579.
OECD. (2025). Practical approaches to develop resilience strategies for food systems. OECD Food, Agriculture and Fisheries Papers. DOI: 10.1787/caa2b274-en.
Opiyo, E. O., Jonathan, C., & Samuel, O. (2021). Preparing for COVID-19: Household food insecurity and vulnerability to shocks in Nairobi, Kenya. PLoS One, 16(11), e0259139.
Peter, K. S. (2015). The impact of economic shocks on child health and education: A review of evidence from developing countries. World Bank Economic Review, 29(1), 1-24.
Placzek, O. (2021). Socio-economic and demographic aspects of food security and nutrition. OECD Food, Agriculture and Fisheries Papers No. 150. Paris: OECD Publishing.
Popkin, B. M., Corvalan, C., & Grummer-Strawn, L. M. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. The Lancet, 395(10217), 65-74.
Quak, E. J., Saha, A., & Thorpe, J. (2022). National governments' support measures for small business during the COVID-19 pandemic: How these measures have affected the resilience of firms and the broader food system. Geneva: Global Alliance for Improved Nutrition (GAIN).
Quisumbing, A. R., & Maluccio, J. A. (2003). Resources at marriage and intrahousehold allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa. Oxford Bulletin of Economics and Statistics, 65(3), 283-327.
Ruel, M. T., & Alderman, H. (2013). Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? The Lancet, 382(9891), 536-551.
Ruel, M. T., & Menon, P. (2002). Child feeding practices are associated with child nutrition status in Latin America: Innovative uses of the demographic and health surveys. The Journal of Nutrition, 132(6), 1180-1187.
Sabarwal, S., Sinha, N., & Berezano, M. (2011). How do women fare during economic crises? Molecular Nutrition & Food Research, 55, 11-25.
Shi, C., Long, X., Xia, S., et al. (2025). Healthy ageing and psychological resilience among the empty-nest older adults: A cross-sectional survey in China. BMC Geriatrics, 25(1). DOI: 10.1186/s12877-025-06081-7.
Smith, L. C., et al. (2003). The importance of women's status for child nutrition in developing countries. IFPRI Research Report 131. Washington, DC: IFPRI.
Stillman, S., & Thomas, D. (2008). Nutrition status during an economic crisis: Evidence from Russia. The Economic Journal, 118(531), 1385-1417.
Swinburn, B., Sacks, G., Vandevijvere, S., et al. (2013). INFORMAS (International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support): Overview and key principles. Obesity Reviews, 14(S1), 1-12.
UNICEF. (2023). Global resilience report: Safeguarding the nutrition of vulnerable children, women, families and communities in the context of polycrisis. New York: UNICEF.
Wang, J., Ding, X., & Fan, S. (2025). Food assistance programs in China: Evolution, challenges and potential for improvement. Applied Economic Perspectives and Policy, 47(1), 65-79.
Worsley, A. (2002). Nutrition knowledge and food consumption: Can education modify food habits? Asia Pacific Journal of Clinical Nutrition, 11(S3), S579-S585.
Xu, X., et al. (2020). Does food knowledge matter? The impact of nutrition knowledge on dietary quality and health during the COVID-19 pandemic. Nutrients, 12(11), 3362.

Yang, Q., Yuan, T., Yang, L., et al. (2019). Household food insecurity, dietary diversity, stunting, and anaemia among left-behind children in poor rural areas of China. International Journal of Environmental Research and Public Health, 16(23), 4778.

Zhou, D., et al. (2022). Climate shocks and rural household consumption smoothing: Evidence from China. World Development, 152, 105784.

Chen, Y., & Zhao, Z. (2012). The impact of rural parents' out-migration on the health of left-behind children in China. Chinese Journal of Health Policy, 5(11), 48-54. [in Chinese]

Cui, S., Zhou, Z., & Kong, X. (2015). Research on the impact of parents' out-migration on the nutrition health of left-behind children: An analysis based on PSM. Rural Economy, (2), 103-108. [in Chinese]

National Health Commission. (2020). Report on the nutrition and chronic disease status of Chinese residents (2020). Beijing: People's Medical Publishing House. [in Chinese]

He, Y., Ye, Z., Fang, Y., et al. (2024). Revision of the Chinese Dietary Balance Index: DBI-22. Acta Nutrimenta Sinica, 46(3), 209-214. [in Chinese]

Jin, X., & Liu, Y. (2017). The impact of caring for grandchildren on the life satisfaction of the elderly: A study based on migrant and non-migrant elderly. Journal of Southeast University (Philosophy and Social Science Edition), 19(2), 11. [in Chinese]

Wang, X., & Lan, Y. (2011). Labor transfer, health of left-behind elderly, and the supply of rural public pension services. Nankai Economic Studies, (4), 21-31. [in Chinese]

Xia, J. (2022). Research on the current situation and influencing factors of dairy product consumption among rural children [Master's thesis]. Beijing: Chinese Academy of Agricultural Sciences. [in Chinese]

Yu, D., He, Y., Guo, Q., et al. (2016). Status and variation trend of dietary energy and macronutrient intakes among Chinese residents from 2002 to 2012. Journal of Hygiene Research, 45(4), 527-533. [in Chinese]

China Internet Network Information Center. (2024). The 53rd statistical report on China's Internet development. Beijing: China Internet Network Information Center. [in Chinese]

Zhu, W., & Li, G. (2023). Study on the impact of price rising shocks on residents' food consumption and nutrition intake: Taking low-income groups as an example. Food and Nutrition in China, 29(10), 35-44. [in Chinese]

## Appendix

**Appendix Table 4-1 International Experience and Chinese Practices for Strengthening Nutrition Resilience**

| Policy pathway | Core measure | International examples | Chinese practices |
|---|---|---|---|
| Social protection and income support | Unconditional cash transfers: Provide cash assistance based on poverty status, eligibility, or citizenship, allowing recipients to decide how to allocate resources. | Income support and universal credit programs in European countries such as the United Kingdom. | Urban and rural minimum living standard guarantee system, or dibao. |
| | Conditional cash transfers: Link cash assistance to shared responsibilities, such as children's school attendance, health check-ups, vaccination, or maternal and child health services. | Brazil's Bolsa Família and Mexico's Oportunidades. | China has not established a systematic national conditional cash transfer program, although some local pilots link assistance to school enrollment, health services, or family services. |
| | Food-based or restricted-use benefits: Provide food vouchers, electronic benefit cards, or restricted-use subsidies that can be used only for food purchases, thereby supporting food access and reducing diversion to non-food uses. | The U.S. Supplemental Nutrition Assistance Program, or SNAP; the UK Healthy Start scheme. | Temporary price subsidy mechanisms linked to the consumer price index, mainly used to support basic living consumption during periods of price increases. |
| | Public works-based relief programs: Provide temporary employment through public works projects, with compensation delivered in cash, food, or other support. Food-for-work and cash-for-work are specific forms of this broader approach. | India's Mahatma Gandhi National Rural Employment Guarantee Act; World Food Programme food-for-work programs in emergency and recovery contexts. | China's work-relief programs, which combine public infrastructure construction with employment creation and income support for low-income rural residents. |
| | Financial support for food-system actors: Provide credit, guarantees, or other financial support to smallholders and micro, small, and medium-sized enterprises in food supply chains to stabilize supply and protect local employment. | Low-interest loans and flexible collateral arrangements for food-related MSMEs in Ethiopia and Nigeria. | Inclusive finance policies, rural microcredit, and financial support for smallholder farmers and food-related micro and small enterprises. |
| Food environment and supply access | Supply-chain optimization: Support local production, procurement, and distribution through public procurement, local procurement, and short supply chains, thereby improving food-system stability and inclusiveness. | World Food Programme local procurement policies; France's regional food projects. | Consumption-based poverty alleviation programs, and designated production bases under the "Vegetable Basket" Mayor Responsibility System. |

| Policy pathway | Core measure | International examples | Chinese practices |
|---|---|---|---|
| Food environment and supply access | Food banks and emergency food assistance: Collect, store, and distribute donated food or emergency food packages to vulnerable groups during shocks, as a supplement to the social safety net. | Global FoodBanking Network, Feeding America, and World Food Programme emergency food assistance programs. | A systematic national food bank network has not yet been established, although some cities have charity-led and community-based food assistance programs, such as Oasis Food Bank. |
| | Forward-looking planning and risk governance: Use scenario analysis, risk monitoring, cross-sector coordination, and early-warning systems to manage food-system risks before they escalate into crises. | Japan's cross-sector foresight studies; London's food resilience advisory group. | Agricultural risk monitoring and early-warning mechanisms led by relevant ministries; national monitoring of residents' nutrition and health status. |
| Nutrition awareness and capacity building | Public nutrition education: Disseminate nutrition knowledge through dietary guidelines, public campaigns, school education, food labeling, and media communication. | Australia incorporates equity considerations into dietary guideline development; the U.S. WIC program combines food support with nutrition education. | National Nutrition Plan (2017–2030); Chinese Dietary Guidelines; nutrition and health education delivered through schools, communities, and primary healthcare institutions. |
| | Institutionalized nutrition services: Move nutrition education beyond short-term projects by embedding it into routine public health, school, and community service systems. | Ghana transferred the Girls' Iron-Folic Acid Supplementation Program from a school-based project to routine delivery through the health system. | Primary healthcare institutions provide nutrition and health education; family doctor contract services increasingly include dietary guidance, especially for chronic disease management. |
| | Nutrition education linked with material support: Combine nutrition knowledge with food assistance, vouchers, supplementation, or meal services so that households can act on nutrition advice under resource constraints. | The U.S. WIC program provides both nutrition education and food vouchers; school meal programs often combine direct food provision with nutrition education. | Nutrition Improvement Program for Rural Compulsory Education Students; nutrition packages for children in poor areas; community-based nutrition guidance linked with maternal and child health services. |
| Targeted nutrition support and intra-household allocation | Targeted nutrition support during the first 1,000 days: Provide specialized nutrition packages, supplementation, and dietary guidance for infants, young children, and pregnant and breastfeeding women to prevent irreversible nutrition damage during critical life windows. | The U.S. WIC program provides specialized food vouchers and nutrition education for low-income pregnant women and children under five; the UK Healthy Start scheme provides milk, fruit and vegetable vouchers, and vitamin supplements. | Nutrition packages for children; maternal and child healthcare services providing targeted support for pregnant and breastfeeding women. |

| Policy pathway | Core measure | International examples | Chinese practices |
|---|---|---|---|
| Targeted nutrition support and intra-household allocation | Nutrition support for school-age children: Provide nutritious meals directly through schools or childcare institutions, reducing the risk that vulnerable children are overlooked in intra-household food allocation. | National school meal programs in Brazil, Ghana, and the United States; during the pandemic, some countries converted school meals into household food packages to maintain service continuity. | Nutrition Improvement Program for Rural Compulsory Education Students, which improves dietary quality by directly providing nutritious meals to rural students. |
| | Meal assistance for older adults: Provide affordable and nutritious meals through community canteens, home delivery, or local meal-service networks, especially for older adults living alone or with limited family care. | Community meal delivery and elderly nutrition programs in countries such as France, Japan, and the United States. | Community elderly canteens and local meal-assistance services; policy efforts such as the Action Plan for Vigorously Developing Elderly Meal Assistance Services. |
| | Family-based nutrition guidance for caregivers: Provide targeted nutrition guidance to those who make household food decisions, especially rural female caregivers, grandparents in skip-generation caregiving households, and caregivers of young children or older adults. | Maternal and child nutrition counseling under WIC and similar community-based nutrition programs. | Nutrition education through maternal and child health services, primary healthcare institutions, family doctor contract services, and community-level health promotion. |

**Source:** OECD (2025); Wang et al. (2024), and compiled by the authors based on relevant policy documents and literature

Chapter 5

# Boosting Resilience of Agrifood Systems Through Synchronization of Financial and Fiscal Instruments

CHENG Enjiang[1,2,3], XING Li[2], and CHEN Kevin[3,4]

1. University of Melbourne, Australia
2. Academy of Global Food Economics and Policy, China Agricultural University
3. China Academy for Rural Development, Zhejiang University
4. International Food Policy Research Institute (IFPRI)

## Key Findings

● This chapter defines the scope of fiscal and financial instruments deployed to enhance the resilience of agrifood systems. The analysis covers core fiscal tools, such as public investment, subsidies, and policy guarantees as methods of government resource allocation, alongside the key financial instruments, including credit, insurance, financial derivatives, and public–private partnership (PPP) investments.

● Financial instruments are key to mobilizing funds and managing risks in building a resilient agrifood systems. Green finance plays a pivotal role in resource mobilization, and green insurance stands out for its ability to buffer shocks and safeguard stakeholders through risk management. Medium- and long-term loans (often development-oriented) provide essential funding for rural infrastructure, as well as food processing and storage equipment, all of which are critical to a resilient agrifood systems.

● Public funds and national financial and monetary policies are major drivers of green finance. Amid increasingly stringent global trade rules, structural shifts are occurring in government support for the agrifood systems, with more public funds being allocated to promote green and resilient systems. National financial policies, central bank monetary tools, and regulatory frameworks have played a crucial role in strengthening the coordination between fiscal and financial support for agrifood systems resilience.

● Blended finance is playing an increasingly important role in strengthening agrifood systems resilience. Public and philanthropic funds typically serve as seed capital to leverage private investment. On the one hand, blended finance amplifies the impact of public and philanthropic funding; on the other hand, it helps ensure efficient fund use in line with market principles. International organizations, philanthropic foundations, and specialized research institutions have emerged as key catalysts in this evolving ecosystem.

## Policy Recommendations

● Strengthen the government's leading role in coordinating fiscal and financial support for agrifood systems resilience. Increase fiscal support for financial instruments that enhance agrifood systems resilience, and guide development finance institutions to expand their investments. Fully use the leverage effect of both central and local government finances, actively develop blended finance, and mobilize greater participation from private capital. At the same time, encourage local governments to establish resilience guarantee funds or risk compensation funds, support coordination between local banks and insurance institutions, and build a multi-tiered and sustainable financing system for agrifood systems resilience.

● Encourage banking and insurance institutions to actively participate in building agrifood systems resilience and improve the resilience finance framework of central banks and regulatory authorities. It is recommended to incorporate agrifood systems resilience into the green or inclusive finance policy frameworks of central banks and financial regulators, and to guide financial resources toward resilience-related areas. Explore the issuance of agrifood systems resilience bonds for agricultural and food enterprises, and encourage banks, insurance companies, and non-bank financial institutions to collaborate on financial product innovation. Improve differentiated regulatory mechanisms, strengthen data support and sharing systems, and provide institutional safeguards for resilience-oriented financing.

● Mobilize international resources, expand channels for resilience building, and support the targeted optimization of policies and financial products. Development finance institutions (DFIs) can establish dedicated funds to support agrifood system resilience, to be used in coordination with loan instruments. Financial institutions should actively connect with global climate funds and participate in cross-border risk-sharing and mutual recognition of standards in agrifood systems. Insurance companies and non-bank financial institutions should actively innovate financial and insurance products, strengthen empirical research, and leverage AI technologies to provide evidence-based support for policy formulation and product development by governments, regulators, and financial institutions. Donor organizations should also actively provide funding for technology, research, and platforms to support agrifood systems resilience.

## 5.1 Introduction

At present, amid the complex interplay of global geopolitical tensions, intensifying climate change, and public safety risks, enhancing the resilience of agrifood systems has become an urgent strategic priority. Strengthening resilience requires moving beyond a narrow focus on short-term production efficiency toward building an agrifood systems that combines long-term stability, improved efficiency, and broad inclusiveness,ensuring that all people have access to safe, nutritious, and sustainable food under all circumstances.

In this context, the international community is building a more systematic and forward-looking support framework through the coordinated use of a range of structured financial and fiscal instruments, promoting a resilience capability leap in which agrifood systems shift from passively responding to risks to actively managing risks. This framework includes not only traditional tools, such as public investment in agriculture, agricultural bank credit, and post-disaster compensation-based agricultural insurance, but also emphasizes long-term strategic investment to drive the transformation, aligning with the philosophies of the holistic agriculture vision and the Grand Food Concept[1].

Through policy guidance and fiscal incentives, private capital, philanthropic funding, and other social resources are being directed toward key resilience-enhancing areas such as climate-smart agriculture, digital food supply chain infrastructure, and multi-level nutrition distribution systems, thereby reducing the overall vulnerability of agrifood systems[2,3]. At the same time, innovative market-based mechanisms,such as climate index insurance, supply chain finance, and sustainability-linked bonds,are being used to effectively transfer and hedge risks across time and space, strengthening stability and resilience across the entire value chain, from production, storage, and trade to consumption and nutrition.

This chapter is structured as follows: Section 1 explains, from theoretical and mechanistic perspectives, the core supporting role of financial and fiscal instruments in enhancing agrifood systems resilience; Section 2 presents practical applications and effectiveness of coordinated financial and fiscal innovation tools; Section 3 further argues that to fully realize these synergies, key institutional mechanisms,including PPP model optimization, deeper cooperation among financial institutions, and regulatory policy coordination,must be strengthened and integrated; and the final section summarizes the chapter and puts forward actionable policy recommendations.

## 5.2 Mechanism Analysis of Fiscal-Financial Synergy in Enhancing Agrifood Systems Resilience

Financial instruments mainly include credit, insurance, financial derivatives, and public–private partnership investments. Fiscal tools by comparison encompass public investment, fiscal subsidies, and policy guarantees as methods of government resource allocation. Different financial and fiscal instruments form a functional spectrum ranging from single to diversified approaches. In practice, through both independent operation and coordinated integration, they can systematically enhance the resilience of agrifood systems along three dimensions: bridging funding gaps, improving risk management, and guiding strategic transformation.

### 5.2.1 Effectiveness and Pathways of Fiscal and Financial Instruments in Supporting Agrifood Systems Development

In recent years, China has introduced a series of policy measures centered on the holistic agriculture vision and the Grand Food Concept, as well as the bottom line of food security. These policies aim to strengthen risk protection across the entire value chain and promote diversified food supply. For example: Documents such as 'the Opinions on Further Deepening

[1] Wang, L. M., Zhang, M. and Duan, L. L. Exploring Research on China's Grand Food Concept (2012-2025): Evolution, Hotspots, and Trends. Chinese Studies, 15, 56-75. doi: 10.4236/chnstd.2026.151004.

[2] The UN Food Systems Summit +4 Stocktake (UNFSS+4) convened in Addis Ababaa, Ethiopia in July 2025. The conference identified financial support and investment mobilisation as core drivers for accelerating agrifood systems transformation, as finance determines success or failure. https://www.unfoodsystemshub.org/un-food-systems-summit-4-stocktake/en#:~:text=As%20we%20approach%20four%20.

[3] Given the distinct public goods attributes of the sector, establishing a coordination framework that integrates fiscal and financial policies is essential. Within this framework, the role of finance and fiscal policy extends far beyond capital provision and risk management; they serve as pivotal levers driving the structural transformation of agrifood systems.

Rural Reform and Solidly Advancing Comprehensive Rural Revitalization' and 'the Opinions on Strengthening Financial Services for Rural Reform and Promoting Comprehensive Rural Revitalization' explicitly call for coordinated efforts between fiscal funds and financial resources. These policies prioritize support for high-standard farmland development; black soil protection and the comprehensive utilization of saline-alkaline land; seed industry innovation platforms such as the Nanfan (seed industry) Silicon Valley; production-area storage and preservation, cold chain logistics infrastructure; an agricultural insurance system centered on full-cost insurance and planting income insurance; and the construction of terminal service facilities such as community senior dining halls and centralized meal-support kitchens. These measures further strengthen the key leverage role of finance and fiscal policies in enhancing the resilience of the agrifood systems.

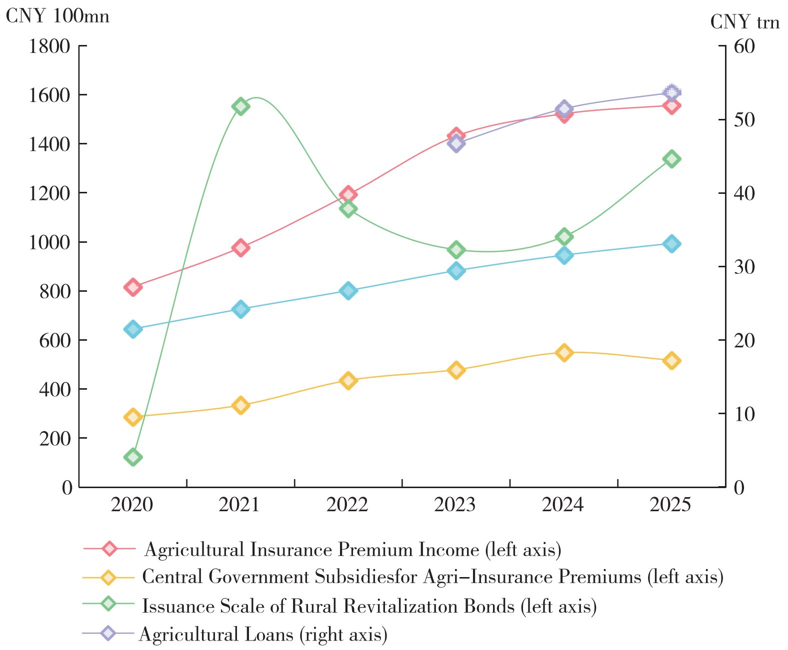
From the perspective of fund deployment, the scale of fiscal and financial instruments supporting agrifood systems and rural revitalization has continued to expand. Data show that by the end of 2025 (Figure 5-1), the outstanding balance of agriculture-related loans in both domestic and foreign currencies reached CNY 53.6 trillion, representing a year-on-year increase of 4.3%. Loans in CNY from major rural financial institutions (including rural credit cooperatives (RCCs), rural cooperative banks, and rural commercial banks (RCBs) amounted to CNY 33.1 trillion, an increase of CNY 1.6 trillion from the beginning of the year. In terms of direct financing, CNY 133.741 billion in rural revitalization bonds were issued throughout 2025, indicating a recovery after a period of slow growth. In risk management, agricultural insurance premiums reached CNY 155.5 billion in 2025, of which CNY 51.7 billion came from central government subsidies. China has now become the world's largest agricultural insurance market, with premium volumes nearly 30 times that at the initial stage in 2007.

As illustrated in the figure, various fiscal and financial instruments play an important role in enhancing agrifood systems resilience, stabilizing production expectations, ensuring capital supply across the entire value chain, and supporting rural infrastructure development and industrial transformation and upgrading. The following section introduces the mechanisms through which major fiscal and financial instruments enhance agrifood systems resilience (Table 5-1).

### 5.2.2 Resilience Financing: Bridging Funding Gaps

Such instruments primarily function as a capital pool, effectively alleviating market failures in the

**Figure 5-1 Growth of Fiscal, Financial and Insurance Tools in Agrifood Systems (2020–2025)**




**Sources:** WIND, Ministry of Finance, Dagong International, AGFEP.

Table 5-1 **Mechanics of Fiscal, Financial Tools in Enhancing agrifood Resilience**

| Function | Mechanism | Key Instruments | Priority Areas |
|---|---|---|---|
| Resilience Financing | Providing sustained, long-term, and stable capital to correct market failures and bridge funding gaps in resilience-building. | Development finance, Public investment, Private funds, Blended finance, Supply chain finance (platforms), Insurance capital, Inclusive finance etc. | Upgrading resilient infrastructure, Technology adoption, Inclusive development.<br>e.g., High-standard farmland, Smart water systems, Digital supply chains, Nutrition dietary service systems. |
| Risk Management | Jointly establishing multi-tiered risk diversification and transfer mechanisms to enhance the system's overall shock absorption and recovery capacity. | Agricultural insurance, Income & Price insurance, Weather index insurance, Inclusive credit, Financial derivatives, Options, Futures, Catastrophe bonds etc. | Multiple risks facing agrifood systems.<br>e.g., Natural disasters, Disease control, Price stabilization, Vulnerable group protection, Geopolitical risks. |
| Strategic Transition | Guiding the system towards green, sustainable production, and healthy and equitable diets through policy incentives. | Green finance (credit, bond etc.), Carbon sink insurance, Green insurance, Featured crop insurance, Blended finance, Consumer credit etc. | Transitioning towards more resilient, green, and inclusive development models.<br>e.g., Climate-smart agriculture, Equitable, healthy, and affordable food systems. |

**Sources:** Compiled by the authors based on publicly available data.

agricultural sector caused by long investment cycles and uncertain returns. Specifically, by coordinating public funds, private capital, philanthropic funding, and insurance funds, they provide patient capital to support improvements in agrifood systems resilience.

(1) Development-oriented loans

Development-oriented loans are concessional and mission-oriented loans provided by national or multilateral development institutions (such as national agricultural development banks, the International Fund for Agricultural Development (IFAD), the World Bank, and regional development banks)[4,5]. Their objective is to promote socio-economic development, with particular emphasis on supporting agricultural and rural infrastructure, and achieving social, environmental, and economic outcomes such as poverty reduction, food security, and agricultural modernization[6,7]. For example, under the 14th Five-Year Plan, the Chinese government has invested more than CNY 100 billion to support farmland irrigation infrastructure, cold chain facilities, agricultural digitalization, and food security systems, while promoting technologies such as smart irrigation and drones[8]. China Development Bank (CDB) and the Agricultural Development Bank of China (ADBC) have provided substantial support for agricultural development through such development-oriented lending.

When countries face shocks such as natural disasters or major public emergencies, they often allow agricultural loans to be extended, defer principal and interest repayments, or even provide emergency loans or restructure loan arrangements. These measures help prevent vulnerable groups,such as farmers and small and micro enterprises,from going bankrupt or falling into debt crises due to short-term shocks. For example, during the COVID-19 pandemic, the Chinese government strengthened direct income support for individuals and households (such as unemployment insurance and expanded social assistance for vulnerable groups), also providing operational buffers for businesses (such as allowing enterprises to defer social security payments) (FAO, 2020).

(2) Government funds (resilience funds and industrial funds)

Resilience funds are typically special-purpose funds established by governments, international organizations,

[4] https://www.ifad.org/en/w/explainers/demystifying-development-finance

[5] A farmer's Guide to Agricultural Credit, AgBiz logic, https://www.agbizlogic.com/static/resources/course_material/A%20FARMER'S%20GUIDE%20TO%20AGRICULTURAL%20CREDIT.pdf.

[6] https://www.ifad.org/en/w/explainers/demystifying-development-finance.

[7] Financing Agricultural Term Investment, FAO. https://www.fao.org/4/y5565e/y5565e05.htm.

[8] https://www.dcz-china.org/2025/03/29/china-releases-new-ag-subsidies-for-2025/

development institutions, or through multi-stakeholder partnerships. Their aim is to enhance the capacity of agrifood systems to withstand, adapt to, and transform in response to multiple risks such as climate shocks, economic fluctuations, pandemics, and conflicts[9]. These funds often prioritize support for smallholder farmers, low-income communities, critical nodes in supply chains (such as storage, transportation, and processing), and ecologically vulnerable regions,groups that are most affected by shocks and are key to system recovery.

At present, China does not have a nationwide fund formally named an agricultural resilience fund or agrifood system resilience fund. However, based on policy practices, instruments such as rural revitalization funds, industrial funds, and seed industry funds, as well as parallel funds established in cooperation with international green climate funds (e.g., the Shandong Green Development Fund and the Weihai parallel fund), generally invest in areas such as ecological restoration and smart water management. In practice, these funds effectively play a role in enhancing the resilience of agriculture and agrifood systems.

(3) Private funds

Private funds mainly include venture capital and equity investment. Table 5-2 shows that private investment hotspots are concentrated in cold chain and logistics infrastructure in major cities and agricultural distribution hubs. Venture capital, meanwhile, tends to focus on digital agriculture and supply chain innovation (such as cold chain e-commerce platforms). These have become major sources of funding for strengthening resilience in the midstream segments of the agrifood systems.

(4) Microfinance / inclusive finance and consumer credit

Microloans and consumer credit can help smallholder farmers manage income volatility and smooth consumption. Microfinance is an important component of inclusive finance. It is characterized by small loan sizes, with borrowers typically being low-income or poor groups, often without collateral requirements. The purpose of such loans is to support entrepreneurship, income generation, and poverty reduction.

In developing countries, farmers often combine income-generating activities and household consumption, making it difficult to separate business and consumption expenditures. As a result, many farmers use part of their microloans for consumption. Interest rates on microloans generally fall between those of commercial banks and informal lending. Studies show that microcredit not only promotes income growth and strengthens the resilience of agricultural production among farmers, but also significantly improves household financial management. Microloans and consumer credit can also help low-income urban groups smooth consumption, thereby improving the resilience of the agrifood systems.

(5) Supply chain finance instruments

Financing instruments within the agrifood supply chain can be used to support both the production and distribution of agricultural products, as well as the supply of agricultural inputs and final consumption. By assessing the entire agrifood value chain, financial institutions can provide loans across multiple segments simultaneously. Some of these loans may have longer maturities, making them suitable for infrastructure investments such as land development, factory construction, and warehouse building, and are therefore appropriate for medium- and large-sized agricultural enterprises or cooperatives[10]. Meanwhile, through agricultural procurement contracts, part of the financing can flow directly to farmers,especially smallholders,thus alleviating financing constraints faced by vulnerable groups[11].

In times of extreme weather, international trade disruptions, or sudden shocks, inventories serve as the most important buffer. Warehouse financing instruments can reduce the seasonal sell-off of crops, stabilizing prices from the supply side. Processing finance can extend the value chain and increase added value, while transportation finance helps address regional supply–demand imbalances, reduce losses, and mitigate price fluctuations caused by logistical constraints[12]. Figure 5-2 lists several innovative supply chain finance instruments.

[9] For references regarding resilience funds supporting resilient agrifood systems, see Keegan et al. (2025); CGIAR (2025); and KC et al. (2025).

[10] Equipment loans are a form of asset-based lending, where the equipment purchased with the loan proceeds serves as the collateral for that loan. Repayment is typically structured in installments over a set period. The financier,such as a bank,monitors the operation and maintenance of the equipment; in cases of default, the lender retains the right to liquidate the collateral (i.e., seize and sell the equipment) to recover the outstanding loan balance.

[11] Financial institutions typically provide financing to the anchor enterprises within the industrial chain,primarily processors and traders.

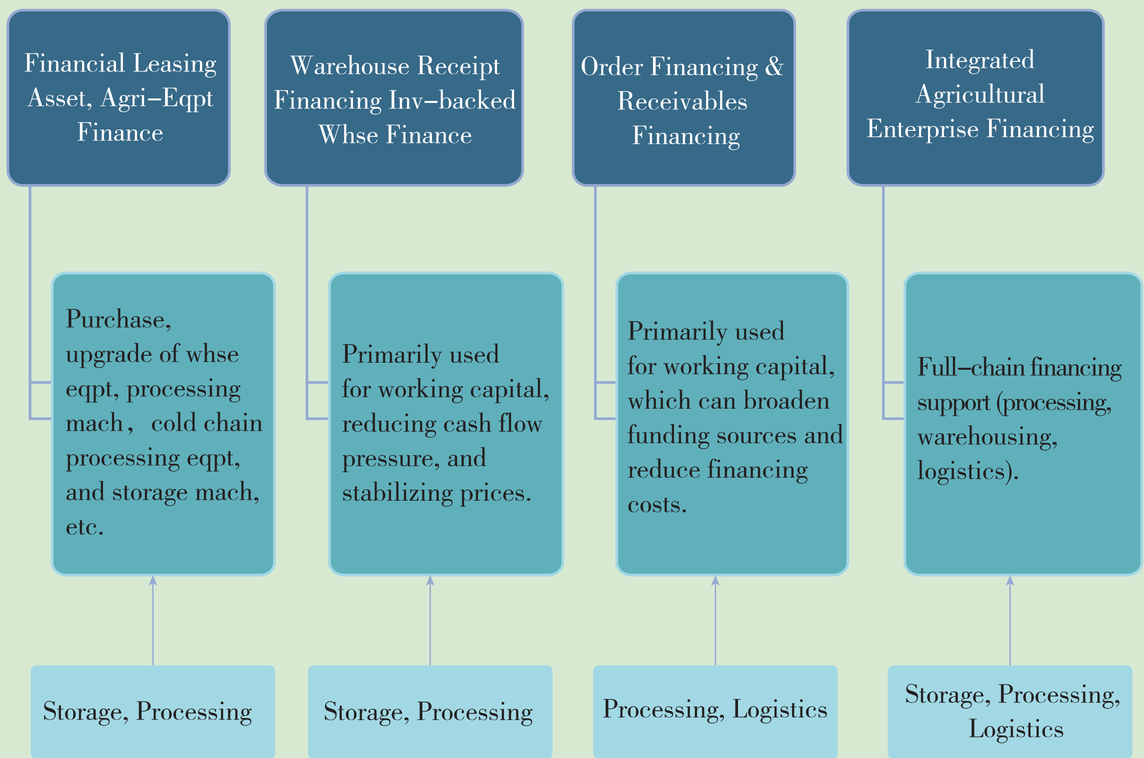
[12] See BCG. (2022);Food and Agriculture Organization of the United Nations. (2021). Kumar, A., & Singh, R. (2020)；United Nations Development Programme. (2021). Jckson, T., & Brander, L. (2019).

**Table 5-2 Cases of Private Fund Investments in China's Agfrifood Sector**

| Category | Fund / Institution | Typical Investment Focus | Representative Case / Amount |
|---|---|---|---|
| Cold Chain, Storage & Logistics | Shenzhen Agricultural Product Circulation Industry Fund | Cold storage, Wholesale markets, Cold chain transport | Invested in Shenzhen Cold Chain Logistics Hub; Registered capital of CNY 136 million. Construction of agri-wholesale markets, cold storage facilities, agri-e-commerce, and environmental projects etc. |
| | Mapletree China Logistics Investment Private Fund (MCLIP) (Managed by Mapletree) | Modern logistics parks, Cold chain warehousing | Approx. USD 900 million in initial equity; covers Tier-1 city logistics hubs. Current AUM approx. USD 1.7 billion. |
| Processing & Supply Chain | China Agricultural Fund | Agri-processing enterprises, Supply chain platforms | Invested in multiple agri-processing enterprises; amount undisclosed. |
| AgTech | Top-tier VC Firms (e.g., Shunwei Capital, GGV Capital, ZhenFund) | Agricultural digitalization, Cold chain e-commerce platforms | Invested in cold chain seafood e-commerce platform; raised tens of millions of RMB. |
| PE M&A | Blackstone, Warburg Pincus, MBK Partners | Cold Chain Storage & Logistics Hubs | In Q1 2024, acquisitions of China logistics assets totaled approximately USD 5.5 billion. |

**Source:** Mapletree[13].

**Figure 5-2 Innovative Financial Instruments in the Agrifood Supply Chain**




**Sources:** Asset Finance for Farming and Agriculture[14]; DLL Agricultural Equipment Finance; The Complete Guide to Agriculture Loans; mcpfinancial.com.au; Agribusiness Finance Broker (MCP Financial).

[13] https://www.mapletreeprivatecapital.com/fund/mapletree-china-logistics-investment-private-fund-mclip/.

[14] https://copilot.microsoft.com/chats/5CNtiqbnh6bhfUTABAS8T.

It is worth noting that in developing countries, processing and storage enterprises are generally small in scale and have low financial transparency, making it difficult for financial institutions to accurately assess risk. To strengthen agrifood systems resilience, governments, insurers, and guarantee institutions need to jointly participate in risk-sharing mechanisms. These may include interest subsidies, agricultural guarantee funds, agricultural insurance combined with price insurance, and other risk compensation mechanisms to encourage financial institutions to provide financing support to agricultural storage and processing enterprises and cooperatives.

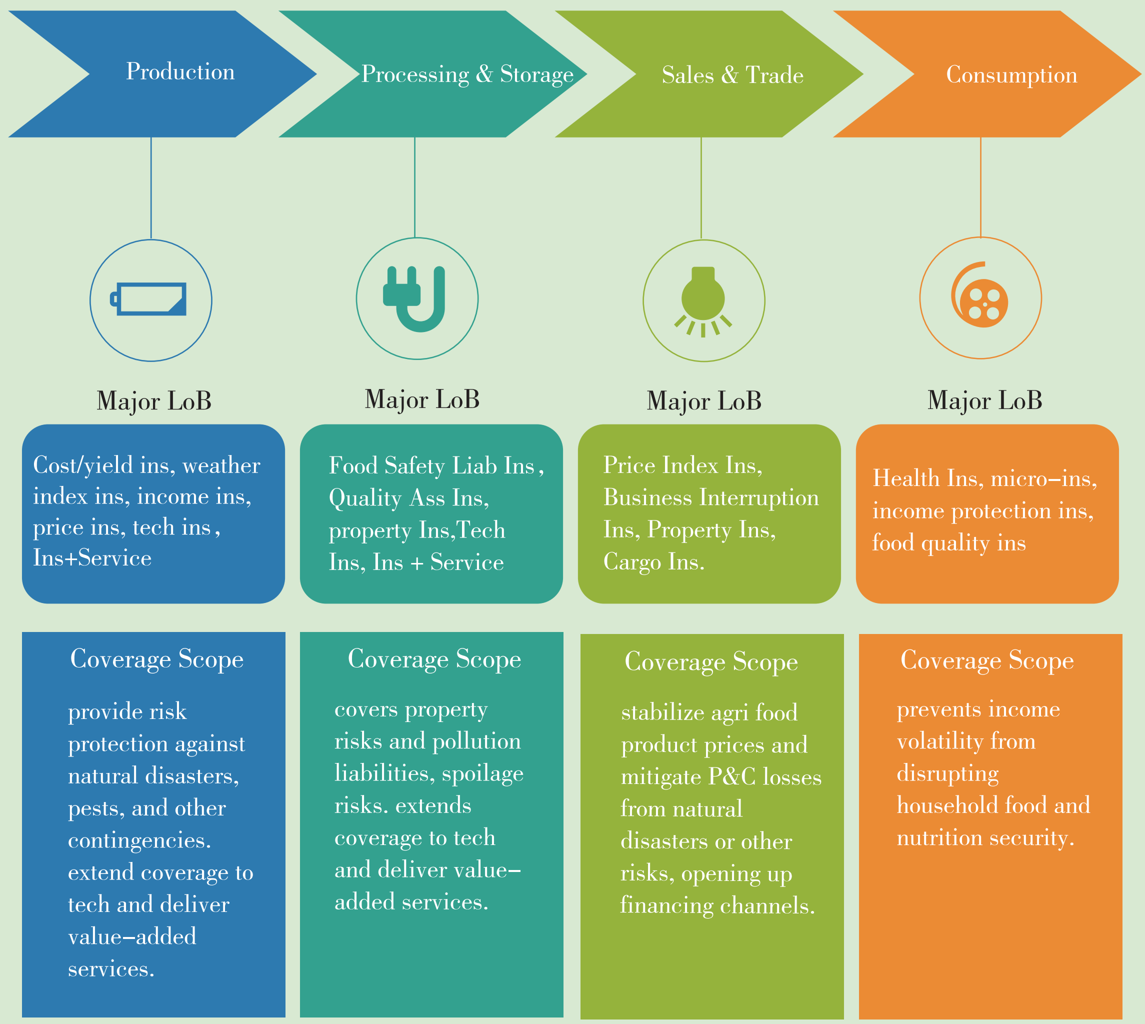
### 5.2.3 Risk Management: Strengthening Risk Prevention

Such instruments mainly function as a buffer, effectively addressing multiple risks,such as natural disasters, disease outbreaks, and market volatility,through the coordinated construction of multi-layered risk management systems. Specifically, fiscal measures provide basic protection through tools such as agricultural insurance premium subsidies, disaster relief funds, and grain reserve systems. Meanwhile, financial markets offer innovative instruments, such as agricultural price insurance and income protection programs, to help actors across the value chain manage price fluctuations and cash flow risks (World Bank, 2007; Swiss Re, 2008). These arrangements also provide buffer support for vulnerable groups, thereby enhancing the overall inclusiveness of the agrifood systems (Figure 5-3).

(1) Agricultural cost/yield insurance

Traditional agricultural insurance mainly targets production-related risks such as natural disasters and pest infestations. It provides financial compensation

**Figure 5-3 End-to-End Risk Coverage of the Agrifood System**




**Sources:** Compiled by the authors.

for input costs or yield losses, helping farmers resume production and secure basic income. Major types include input cost insurance, yield insurance, multi-peril crop insurance (MPCI)[15], and single-risk crop insurance (Hazell et al., 2010; FAO, 2019) (Table 5-3)[16].

(2) Weather index insurance

Weather index insurance  is an innovative risk transfer tool based on satellite remote sensing and meteorological data. It helps mitigate moral hazard, encourages disaster risk reduction, and lowers operating costs and premiums. Its standardized index structure also facilitates integration with international reinsurance markets, making it a highly effective solution for agricultural risk management (World Bank, 2005).

A large body of empirical research has examined the advantages and challenges of climate index insurance. Karlan et al. (2014) find that well-designed agricultural index insurance significantly increases farmers' willingness to take risks, encouraging the adoption of improved technologies and management practices, thereby enhancing climate adaptability and long-term productivity. Hess and Hazell (2016) point out that the efficiency advantages of index insurance make it particularly suitable for rural areas with weak infrastructure and limited underwriting capacity.

In China, more than 100 pilot projects for agricultural weather index insurance have been implemented. Typical products include drought index insurance, low-temperature frost insurance, precipitation index insurance, and composite meteorological index insurance covering conditions such as hot dry winds and prolonged cloudy and rainy weather. A multi-agency system,led by the government and involving agriculture, meteorological, and insurance departments,has gradually taken shape[17].

(3) Price insurance and revenue insurance

Price insurance specifically addresses the risk of falling agricultural product prices, providing compensation when market prices drop below a predetermined target level. Income insurance, by contrast, integrates both yield and price risks, using farmers' unit income (yield × price) as the insured target, thus offering a more comprehensive solution (Goodwin et al., 1995).

Price and income insurance stabilize farmers' income expectations, fundamentally influencing their production decisions and providing a risk buffer for agricultural modernization. The rapid expansion of income insurance products (such as Crop Revenue Coverage, CRC) under the U.S. Federal Crop Insurance Program (FCIP) illustrates this trend (Dismukes et al., 2006).

The insurance + futures model is an innovative form of price insurance. Under this mechanism, insurance companies design and sell price (or income) insurance products to farmers based on futures market price data, and then transfer the systemic price risk they underwrite to the futures market for hedging by purchasing over-the-counter options from subsidiaries of futures firms. This model is particularly suitable for bulk commodities such as soybeans and corn that have mature futures markets, and can effectively hedge price risks in corn income insurance (Tiwari, 2017), thereby enhancing farmers' incentives to produce grain (Fang Rui et al., 2019).

(4) Insurance solutions for the food industry

Insurance services also extend across the entire farm-to-table process,from agricultural production and processing to transportation and retail,covering a wide range of risks. Accidental contamination during production, unintended third-party introduction of hazards, or temperature control failures during logistics can all lead to product spoilage or damage. The resulting product recalls, consumer health claims, and reputational damage can impose severe economic losses on firms and negatively affect consumer nutrition and health.

To address these complex challenges, insurance solutions not only include traditional coverage such as public and product liability insurance, property insurance, and business interruption insurance, but also expand to industry-specific products. These include malicious product tampering and extortion insurance, product recall insurance, specialized coverage for key production equipment (such as fryers and thermal fluid systems), and logistics protection (including cargo insurance and cold chain interruption insurance). Some policies even

[15] MPCI covers crop yield reductions caused by multiple risk factors, including drought, floods, freezing injury, hail, strong winds, plant diseases, and other natural disasters.

[16] Single peril insurance covers crop yield reductions triggered by specific risk factors, such as hail or windstorms.

[17] Currently, Most premium subsidies come from the central government. Yet uneven local fiscal capacity and a lack of supporting technical infrastructure still hinder the scaling of index insurance in some regions. See "IIGF Opinion | Zhou Zhou and Guo Zidan: Analysis on the Development and Future Prospects of Agricultural Weather Index Insurance, International Institute of Green Finance, Central University of Finance and Economics.

**Table 5-3 Classification of Agricultural Cost/Yield Insurance Products**

| No. | Category | Classification & Insurance Coverage |
|---|---|---|
| 1 | Crop Insurance | Covers cultivated plants, including food crops and cash crops. It compensates for input costs or yield losses caused by natural disasters, pest infestations, or accidents. |
| 2 | Forestry Insurance | Covers cultivated forests and fruit tree orchards. It compensates for replanting costs or yield losses caused by disasters such as fire, pests, and windstorms. |
| 3 | Livestock & Poultry Insurance | Covers raised livestock and poultry. It covers economic losses arising from the death or disability of animals caused by disease, natural disasters, or accidents. |
| 4 | Aquaculture Insurance | Covers aquatic products raised in controlled water environments. It covers economic losses caused by natural disasters and accidents. |
| 5 | Specialty Agricultural Product Insurance | Insurance products developed for local specialty agricultural products to meet the specific risk protection needs of different agricultural sectors. |

**Sources:** Selected from CAFI, White Paper on the High-Quality Development of Inclusive Insurance (2025), November 2025.

cover income losses caused by specific risks such as weather, pests, or disease. Together, these solutions help enterprises build comprehensive risk protection systems while safeguarding consumer nutrition and health.

(5) Inclusive insurance

Inclusive insurance products targeting vulnerable groups and micro and small enterprises (MSEs) within the agrifood system are receiving increasing attention. They play a crucial role in linking production and consumption and supporting the localized functioning of supply chains (Reardon et al., 2021).

These products create a basic risk safety net by providing essential protection, including supplementary health insurance for vulnerable groups, life insurance to address financial risks associated with the death of a household breadwinner, and accident insurance. For small and micro enterprises, commercial insurance systems may include a portfolio of products such as property insurance (protecting business assets), business interruption insurance (covering profit losses due to operational disruptions), export credit insurance (mitigating international trade risks), guarantee insurance (facilitating access to financing), and liability insurance (addressing potential liabilities), enhancing risk protection for vulnerable groups (Beiduo Guang and Xing Li, 2025), and preventing declines in household and individual dietary nutrition caused by falling household income.

(6) Futures and Options

Futures and options, as important financial derivatives, play an irreplaceable role in managing price risks in agricultural products and food markets. The mechanism of futures markets,locking in future trading conditions in advance,makes them a core tool for coping with price volatility (Mintert et al., 1999). Producers can use the futures market to conduct short hedging operations, locking in future selling prices and avoiding the risk of price declines (Purcell and Koontz, 1999).

Options provide a form of price insurance. When market prices fall, option holders can exercise their rights to receive compensation; when prices rise, they can choose not to exercise and instead benefit from the higher market price. This is particularly suitable for agricultural producers with weaker risk tolerance and can significantly enhance the operational resilience of micro-level actors (FAO, 2006).

So far, in terms of stabilizing agricultural supply and market prices, the main beneficiaries of China's agricultural futures markets have been agricultural processing and trading enterprises, feed companies, rather than farmers or agricultural production enterprises. The agricultural options market shows a similar pattern: major participants include feed companies (New Hope, Haid, Chia Tai), grain and oil processors (COFCO, Yihai Kerry), livestock enterprises (Muyuan, Wens), egg producers (e.g., Jilin Jinying Egg Products), and starch processors (COFCO Biotech). Farmers typically do not trade options directly, but can obtain price protection through insurance + futures.

(7) Catastrophe Bonds

Catastrophe bonds (Cat Bonds) are innovative insurance linked securities designed to transfer and securitize catastrophic risks. Essentially, they shift extreme risks,traditionally borne by the insurance industry and characterized by low frequency but high losses,into the global capital market, which has greater capacity and more diverse risk preferences (Cummins and Weiss, 2009). Since their emergence in the 1990s, the catastrophe bond market has expanded from covering single risks such as U.S. hurricanes and earthquakes to a wide range of global natural disasters (e.g., European windstorms, Japanese typhoons), and even newer risks such as life insurance risks and cybersecurity risks. They have become a model of deep integration between insurance and capital markets, providing crucial capital support for managing increasingly severe extreme weather risks driven by climate change.

According to Aon, as of June 2025, catastrophe bonds remain a key growth area in the insurancelinked securities market, helping address catastrophic risks associated with climate change[18]. Countries and regions such as Mexico[19] and the Caribbean Catastrophe Risk Insurance Facility (CCRIF)[20] have repeatedly issued such bonds to establish pre-disaster financing mechanisms for earthquakes, hurricanes, and other hazards,replacing inefficient and uncertain post-disaster relief and international aid. This securitization of fiscal vulnerability represents a financial innovation in national resilience building. In 2015, China successfully issued its first catastrophe bond covering earthquake risk in overseas markets, strengthening the financial capacity to withstand seismic shocks[21].

[18] Aon, ILS Annual Report, for the perild from July 1,2024-June 30, 20025. Septermber 2025.

[19] Climate Finance Series ② | Building a Risk-Sharing System: Catastrophe Bonds as a Pressure Relief Valve for Public Finance. Available at: https://www.sohu.com/a/810092292_617377.

[20] Xie Shiqing. "Operation and Implications of the Caribbean Catastrophe Risk Insurance Facility." Finance and Economics (Caijing Kexue), no. 1 (2010): Total Issue No. 262.

[21] China Insurance News. (2015, July 6). China's first catastrophe bond issued in the offshore market. https://www.chinare.com.cn/zhzjt/441147/mtgz/2022010703273284839/index.html

### 5.2.4 Strategic Transformation: Green, Healthy, and Nutrition Resilience

Acting as a transformer, policy incentives and financial innovation,such as green financial instruments, sustainability-linked bonds, agricultural carbon-sink insurance, and green funds, guide food system actors to shift from prioritizing short-term efficiency to pursuing long-term resilience and green, sustainable development.

On the consumption side, encouraging green, low-carbon, and healthy lifestyles and optimizing dietary structures not only reduces resource waste and environmental pollution but also drives the food system to upgrade toward more sustainable and higher-value-added directions.

(1) Green Finance (including credit, insurance, bonds, etc.)

According to the United Nations Environment Programme, green finance refers to the systematic integration of environmental, social, and governance (ESG) factors into financial decision-making to direct capital toward sustainable development and climate action[22]. China provides a more specific definition: financial services,including investment, financing, project operations, and risk management, supporting environmental improvement, climate-change mitigation, and efficient resource use[23]. Typical green financial products include green bonds, green loans, and green insurance.

According to the National Development and Reform Commission (NDRC), China's green bond market has expanded rapidly, with issuance ranking first in the world. From 2016 to 2024, annual green bond issuance grew from 201.8 billion yuan to 683.3 billion yuan, an average annual increase of 16.5%. From January to November 2025, issuance reached about 914.9 billion yuan, significantly higher than the full-year 2024 total of 681.4 billion yuan. By the end of 2024, China's outstanding green bonds totaled 2.2 trillion yuan, mainly invested in clean energy, green infrastructure, and energy

[22] United Nations Environment Programme. (n.d.). How China is building a more sustainable financial system. https://www.unep.org/zh-hans/xinwenyuziyuan/gushi/zhongguoruhejianligengkechixudejinrongtixi

[23] People's Bank of China, Ministry of Finance, Ministry of Environmental Protection, et al. (2016). Guidelines for establishing a green financial system.

conservation and environmental protection[24]. Green bond interest rates are generally lower than comparable conventional bonds, especially those issued by major state-owned banks[25]. Although current green-bond investment in food-system resilience remains limited, the potential is substantial and provides a large pool of capital for agricultural green infrastructure.

China's green loan balance has also continued to grow[26]. In the first three quarters of 2025, green loans reached about 43.5 trillion yuan, up 18.9% from the end of 2024. New green loans in 2025 totaled 6.47 trillion yuan, accounting for 43.9% of all new loans. By the end of 2024, the green loan balance had exceeded 35 trillion yuan[27].

In recent years, China's green insurance sector has also made significant progress. According to the National Financial Regulatory Administration, in 2023 green insurance premium income reached CNY 229.7 billion, with CNY 121.5 billion in claims paid. The product range has expanded from environmental pollution liability insurance to catastrophe insurance, carbon insurance, and more, forming a diversified product system. On the asset side, green investments by insurance funds have grown rapidly, reaching CNY 1.67 trillion by mid-2023.

(2) Blended Finance

Blended finance refers to the combination of public funds (government, international institutions, philanthropic funds, grants) with private capital to support socially beneficial but highrisk projects,especially in sustainable development sectors in developing countries[28]. Public funds act as a catalyst, reducing investment risk and attracting private capital into markets that would otherwise be unattractive.

Blended finance typically focuses on the UN Sustainable Development Goals (SDGs), such as agriculture, climate, and infrastructure. Its main goal is to mobilize private investment for high-social-value but uncertain-return projects, supporting green agriculture, climate resilience, poverty reduction, and food security, thereby promoting long-term social and environmental benefits.

Blended finance improves funding efficiency by using public funds for catalytic purposes rather than covering full costs. Through technical assistance, training, and market-access support, it helps projects achieve commercial viability and social impact. It also strengthens foodsystem resilience by mobilizing social capital to support smallholder climate adaptation, sustainable agricultural technologies, and inclusive supply-chain development,accelerating systemic transformation.

A defining feature of blended finance is its risk-sharing structure, where concessional funds absorb part of the risk to encourage private participation. Tools include credit guarantees, first-loss capital, concessional loans, and technical-assistance funds. Effective blended finance emphasizes additionality (mobilizing capital that would not otherwise flow), leverage (using limited public funds to attract larger private investment), and impact orientation (ensuring measurable contributions to resilient food-system development).

## 5.3 Typical Cases of Fiscal–Financial Coordination Supporting Agrifood Systems Resilience

Fiscal and financial instruments reshape the food system through capital flows, serving as key levers for enhancing the system's ability to cope with price volatility, natural disasters, financing constraints, and the resilience of nutrition supply at the consumption end.

The following three representative cases illustrate different pathways through which fiscal and financial tools support food-system resilience: (1) insurance innovation to mitigate price risks, (2) blended finance to fill funding gaps, and (3) fiscal–financial integration to enhance nutrition resilience.

[24] National Development and Reform Commission. (2025, September 1). China's green bond market ranks first globally. https://www.ndrc.gov.cn/wsdwhfz/202509/t20250901_1400200.html

[25] Industrial Bank Research. Review and outlook of commercial banks' green financial bonds market[EB/OL]. (2026-01-14)[2026-01-14]. https://finance.sina.com.cn/stock/relnews/cn/2026-01-14/doc-inhhfrtc4194656.shtml

[26] While Chinese standards for green bonds and loans are converging with global norms, differences remain. Chinese criteria tend to be more inclusive, whereas international standards place greater weight on carbon reduction and third-party verification.

[27] International Institute of Green Finance (IIGF), Central University of Finance and Economics. Research Report on Green Finance[EB/OL]. (2024)[2026-06-10]. https://iigf.cufe.edu.cn/info/1012/10214.htm

[28] Two widely cited definitions frame the concept:
Wikipedia: Blended finance employs development capital and philanthropic funds as catalysts to mobilise private capital into emerging and frontier markets, generating outcomes beneficial to both investors and communities.
OECD: Blended finance seeks to stimulate private investment in low- and middle-income countries by using development funds to assume higher-risk positions, combining them with private finance to foster sustainable development.

### 5.3.1 Insurance Innovation: Insurance + Futures for Managing Agricultural Price Risks[29]

China's Insurance + Futures model is an agricultural risk-management innovation with Chinese characteristics, promoted continuously in the No. 1 Central Document since 2016. Its core objective is to use financial-market tools to provide market-based protection for farmers,especially smallholders,against agricultural price volatility, thereby reducing direct government intervention in agricultural prices and gradually shifting agricultural support policies toward Green Box measures.

The basic mechanism operates as follows: farmers purchase a price-insurance product from an insurance company; the insurance company buys put options from a futures company (paying an option premium) to transfer its price-risk exposure to the futures market; the futures company then hedges its own risk through strategies such as replicating options on the futures exchange, ultimately dispersing the risk to market investors. This design addresses the high entry barriers and limited financial-market knowledge that prevent smallholders from directly participating in futures markets, offering inclusive price protection through the familiar format of insurance.

Pilot programs are typically supported by local-government premium subsidies, and the Dalian Commodity Exchange (DCE) and Zhengzhou Commodity Exchange (ZCE) provide special funding and standardized option products to reduce early-stage transaction costs and technical barriers.

The pilots have evolved from small, region-specific, single-commodity experiments into a more mature, widely applied model. Early pilots (e.g., DCE's 2015 corn and soybean projects) were small and simple. With accumulated experience, more integrated models such as Insurance + Futures + Contract Farming emerged, linking price protection with downstream sales channels and further stabilizing farmers' expected income.

The actuarial core lies in setting the target price and the payout trigger. The target price is usually based on the average futures price during the insurance period or determined by adding/subtracting basis from the futures price. When the actual average futures price falls below the target price, the insurer compensates farmers for the difference. This index-based payout mechanism avoids complicated individual loss assessments and enables rapid compensation.

However, it also introduces the model's biggest challenge,basis risk: the gap between local spot prices and futures prices. If local prices fall sharply due to supply–demand imbalances, even if futures prices trigger compensation, payouts may not fully cover farmers' actual losses. Thus, successful pilots require commodities with mature futures markets, strong price-discovery functions, and high correlation between local spot and futures prices (e.g., soybeans, corn, cotton, sugar).

Over nearly a decade, the model has achieved significant results:

● It has greatly increased awareness of market-based risk-management tools among farmers.

● It has provided effective income compensation during price-decline cycles in many pilots.

● It has fostered a new service ecosystem linking agriculture and finance, building product-design and service capabilities among insurers and futures companies.

However, limitations remain. Beyond basis risk, cost and sustainability are major concerns. Premiums are funded mainly by exchanges, local governments, and farmers, with subsidies accounting for the majority. This heavy reliance on external subsidies raises questions about long-term scalability. There is also tension between standardization and customization: standardized products are easier to scale but may not fit diverse local needs, but customized products increase costs. Finally, the model depends heavily on the depth and efficiency of the futures market; insufficient liquidity or price manipulation would undermine the entire risk transfer chain.

### 5.3.2 Blended Finance: IFAD's Support for Hunan's Specialty Forestry Development

Forestry accounts for about 11% of Hunan

[29] References for this case:
Li, Yaru, and Sun Rong. 2017. "Agricultural Product Futures Price Insurance and Its Role in Price Mechanism Reform." Insurance Studies, no. 3: 90–102.
Li, Zhengqiang, and Zhao Liang. 2023. Research Report on the Development of China's 'Insurance + Futures' Model. No. 12 (Vol. 90). Insurance Theory and Practice: 40–59.
Fang, Rui, An Yi, and Liu Wenchao. 2019. "Can the 'Insurance + Futures' Pilot Improve Farmers' Grain-Growing Incentives?,An Analysis Based on the Mediating Effect of Farmers' Willingness to Participate and the Moderating Effect of Satisfaction with Government Subsidies." Chinese Rural Economy, no. 6.

Province's GDP and forms an important foundation for its green-industry development. However, Hunan is also one of the regions in China most prone to natural disasters, and climate risks frequently threaten farmers' livelihoods. The International Fund for Agricultural Development (IFAD) supports the Hunan Specialty Forestry Industry Development Project, which aims to enhance smallholder production capacity, improve market access, and strengthen ecological sustainability and climate resilience through an enterprise-led, farmer-participatory green-growth model,thereby contributing to China's rural revitalization and carbon-neutrality goals.

This is a typical blended-finance project as well as a green-agriculture investment initiative, involving the construction of green demonstration bases, processing upgrades, and market linkage. Project preparation began in 2024, implementation formally started in 2025, and completion is planned for 2028. A total of approximately USD 235 million will be invested jointly by the Chinese government, IFAD loans, and private enterprises. Among this:

● IFAD provides an USD 80 million loan, guaranteed by the Chinese government.

● The remaining USD 155.2 million is cofinanced by the Chinese government, private enterprises, and project participants.

The project aims to strengthen planting and processing capacity, promote enterprise-led green agricultural development, and enhance market-access mechanisms to better connect smallholders with high-value agricultural value chains. It covers 128,000 smallholder households in Hunan Province, with a six-year investment period. The project is expected to boost Hunan's forestry GDP, optimize agricultural structure, and achieve both sustainable income growth and ecological protection[30].

The project consists of three major components:

● Integrating smallholders into value chains: supporting farmers' participation in specialty forestry industries (e.g., camellia oil, bamboo and timber, understory economy).

● Enterprise-led inclusive business development: enabling leading enterprises and cooperatives to drive smallholder participation.

● Project management and capacity building: including training on green production and climate adaptation.

Blended finance plays several key roles in this project. First, it mobilizes multiple funding sources and expands investment scale. IFAD's USD 80 million loan acts as catalytic capital, attracting an additional USD 155.2 million from government, enterprises, and farmers, bringing the total to USD 235.2 million. This is a classic blended-finance structure: public funds reduce risk and crowd in private capital. Second, the project reduces the risks for private enterprises investing in green agriculture. Forestry investments are known for long cycles and uncertain returns. IFAD's involvement provides long-term, low-cost financing and an international-standard project-management framework. The introduction of climate-riskmanagement tools further reduces enterprise concerns and encourages them to engage smallholders. Third, the project promotes smallholder integration into value chains. In simple terms, the blended-finance structure enables:

● enterprises to access capital for processing, storage, logistics, and branding

● farmers to receive training, technology, and market access

● public funds to ensure inclusiveness and sustainability

This forms a coordinated model of public sector+ enterprises + farmers. Through blended finance, the project not only provides funding but also establishes enterprise-led business models, incentives for sustained farmer participation, and market-driven value-chain systems,ensuring the project continues to operate even after IFAD exits[31].

### 5.3.3 Fiscal-Financial Coordination to Enhance Nutrition Resilience: Zhanjiang's School Meal e-Management Platform[32]

Campus food safety and nutrition security are

[30] International Fund for Agricultural Development (IFAD). "IFAD, China, and Private Sector Invested in Enterprise-Led Green Agricultural Development and Rural Revitalization." Press Release. April 7, 2025. Available at: https://www.ifad.org/en/w/news/ifad-china-and-private-sector-invest-in-enterprise-led-green-agricultural-development-and-rural-revitization.

[31] *Ibid.*

[32] *Zhanjiang Municipal People's Government and Zhanjiang Municipal Bureau of Education. "Official Circulars and Media Reports on the Launch of the 'Xueshan e-Management' Platform." 2025–2026.*

fundamental to the healthy development of young people and to social stability. For a long time, under the contracted-canteen model, school cafeterias faced problems such as incomplete ingredient-traceability systems, opaque fund management, and insufficiently scientific meal planning. These issues made supervision difficult and increased safety risks.

To address both the contracting chaos and the limitations of manual, laborintensive oversight, Zhanjiang City in Guangdong Province has, since 2025, systematically advanced a reform toward self-operated school canteens. It has also innovatively introduced financial institutions into the supervision system. Through digital and closed-loop management mechanisms, the city has built a comprehensive campus food-safety and nutrition-security system covering procurement, processing, and meal provision. The core innovation of this case lies in the coordinated model of fiscal leadership, bank financing, and full-process digital risk control. The mechanism operates as follows:

First, bank capital replaces direct fiscal investment. Through competitive negotiation, the Bank of China's Zhanjiang branch invested more than CNY 30 million to build the School Meal eManagement smart-supervision platform and supporting hardware (smart electronic scales, AI sampleretention devices, etc.). Schools and regulators access the system at zero cost, easing the fiscal burden of large upfront expenditures.

Second, closed-loop supervision of meal funds. A closed fundflow system is established among parents, a bank-supervised account, and suppliers. Parents' meal payments go directly into a dedicated Bank of China supervision account, physically separated from the school's general account. Using financialgrade riskcontrol models, the platform verifies the compliance and price reasonableness of every expenditure in real time, ensuring that the roughly CNY 1.5 billion in annual meal funds are used exclusively for their intended purpose.

Third, full-process digital governance. The platform integrates five modules,transparent procurement, open-kitchen monitoring, nutrition meal planning, consumption management, and financial management,creating complete data traceability from ingredient weighing and storage to final consumption.

Through the deep integration of institutional design + technology + finance, the system has achieved notable results in nutrition and health protection. A total of 1,728 schools has opened dedicated canteen accounts, and 1,706 have connected to the School Meal eManagement system. AI algorithms automatically detect risks such as expired certificates or abnormal inventory, greatly improving earlywarning and response efficiency and shifting supervision from manual defense to technological defense. The platform's built-in nutritional-meal module helps schools design menus and control costs, ensuring students receive diverse and nutritious meals at affordable prices (e.g., steamed chicken with cordyceps flowers, tomato scrambled eggs). Smart weighing and real-time data synchronization eliminate underweighing and inflated procurement prices. For some ingredients, costs have fallen by 5–10% through a centralized procurement, decentralized contracting model, achieving both cost reduction and quality assurance.

Zhanjiang's School Meal eManagement platform is a model of how fiscal leverage can mobilize financial resources to support public nutrition and health. By integrating banks' risk-control and fund-supervision capabilities into the education sector, the system not only safeguards food safety but also ensures the affordability and sustainability of school meals through precise fund management. It provides a replicable approach for building resilience in large-scale schoolmeal systems.

## 5.4 Building a Comprehensive Policy Support System for Fiscal-Financial Coordination

### 5.4.1 Resilience-Oriented Coordination of Fiscal and Financial Instruments

To better align the financial and fiscal tools discussed above with the functions needed to support food-system resilience, we compare various financial instruments with the three main resilience functions of the food system and examine their application in China. Most financial and fiscal tools serve more than one resilience function.

In Table 5-4, only the most prominent or primary resilience function of each tool is listed. From Table 5-4, several observations emerge. First, most financial instruments primarily support risk response and recovery. Risk-buffering tools are especially strong in these areas.

**Table 5-4 Functional Analysis of Financial-Fiscal Instruments Synergies**

| Category/Instrument | Capacity Building & Risk Prevention | Risk Response & Recovery | Resource Allocation & Sustainable Development |
|---|---|---|---|
| 1. Capital Supply Tools | | | |
| Medium-&Long-term Loans and Development Loans | Yes | | Yes |
| Government & Private Funds | Yes | | Yes |
| Supply Chain Finance | Yes | | Yes |
| 2. Risk Buffering Tools | | | |
| Insurance Products (Yield, Price, Income) | | Yes | |
| Microloans & Consumer Loans | | Yes | |
| Financial Derivatives(Futures, Options, Cat Bonds) | | Yes | |
| 3. Transition-Driven Tools | | | |
| Green Financial Products | Yes | Yes | Yes |
| Carbon Insurance | | Yes | |
| Blended Finance | Yes | Yes | Yes |

**Sources:** Compiled by the authors.

Second, medium-and long-term loans and development-finance loans mainly support capacity building and sustainable development. Finally, fiscal policies and related expenditure tools (such as subsidies) play a crucial role in enabling many of the financial instruments listed in the table. For example, medium-and long-term loans (via developmentfinance institutions or interest subsidies), agricultural insurance, income insurance, and inclusive insurance (via premium subsidies and operational subsidies), government–private funds (via fiscal contributions), green-finance products.

This also highlights the significant role that blended finance, as a transformational financial approach, can play in strengthening agricultural resilience. China has already applied or piloted all the tools listed in Table 5-4 except catastrophe bonds.

It is worth noting that financial and fiscal tools can be combined to manage multiple risks simultaneously. For example, agricultural processing or storage enterprises can use loans and other financing tools to adjust the timing of product sales to avoid low-price periods or capture high-price periods (e.g., through processing, storage, or delayed livestock marketing). This is a form of time arbitrage (William & Kaise, 2014). Forward-pricing of agricultural inputs (cost locking) is another important risk-management tool. By signing long-term contracts at the beginning of planting or breeding seasons, producers can lock in the prices of key inputs (seeds, fertilizers, pesticides, feed), leaving only output-price risk to manage (USDA, 1999). If multiple risk-management tools are used together,such as locking in selling prices through futures while managing yield and input-cost risks,overall cash flow can be stabilized or profits locked in (Coble & Barnett, 2013).

### 5.4.2 Building a Collaborative Ecosystem for Food-System Resilience

(1) Public–Private Partnerships (PPP)

In major infrastructure and public-risk domains, public–private partnerships (PPP) have proven to be an efficient mechanism for risk-sharing and resource allocation. By combining the public sector's policy guidance and risk-buffering capacity with the private sector's financial efficiency and technological innovation, PPPs can reduce fiscal pressure, improve public-service delivery, and strengthen resilience against major risks. They are widely recognized as an important governance tool for optimizing infrastructure projects and improving life cycle performance (World Bank PPP Knowledge Lab)[33].

Compared with traditional government procurement, PPPs integrate design, construction, financing, operation, and maintenance, incentivizing private partners to innovate and reduce life cycle costs while transferring certain risks (construction, operational) to the party best able to manage them (Engel et al., 2014). However, PPP success depends heavily on sound contract design and effective implementation; poor risk allocation or performance incentives can lead to cost overruns, service deterioration, or project failure (Hodge & Greve, 2007).

(2) Collaboration Among Financial Institutions

With financial deregulation (e.g., EU Second Banking Directive, 1989; U.S. Gramm–Leach–Bliley Act, 1999) and advances in information technology, bank–insurance cooperation has rapidly expanded,from simple product distribution to complex business integration. Financial conglomerates and mixed banking–insurance operations have become increasingly common (Braun et al., 2019).

By combining banks' funding capacity with insurers' risk-protection functions, such cooperation lowers financial-access barriers, mitigates market failures caused by information asymmetry, and enables highrisk clients to obtain needed financing,enhancing their economic resilience and creating a market-based multi-risk-buffering mechanism for the food system. Field experiments in Malawi further show that index-insurance-linked bank loans can effectively encourage farmers to adopt high-risk, high-return technologies, amplifying the productivity impact of financial resources (Giné et al., 2009).

Financial institutions should also collaborate with external data providers and other partners. The key is breaking data silos, integrating diverse information sources, accurately identifying risks, developing tailored products, and enabling timely interventions. With the future integration of remote-sensing loss assessment, blockchain smart contracts, and AI models, collaboration among financial institutions and digital-technology providers will significantly enhance service efficiency and coverage accuracy, supporting food-system resilience.

### 5.4.3 Strengthening Coordination Between Monetary Policy and Financial Regulation

Central banks and financial regulators play important roles in supporting food-system resilience.

On the monetarypolicy side, central banks can use relending facilities to lower interest rates and provide liquidity, easing agricultural financing pressures[34]. Relending is a policy tool through which the central bank provides liquidity to commercial banks while specifying the intended use,for example, the People's Bank of China's long-standing agricultural relending programs for rural credit cooperatives (now rural commercial banks or agricultural unions).

The NDRC and the central bank can also play active roles in issuing food-system resilience bonds, green bonds, and securitizing assets of food-system enterprises and resilience funds.

On the regulatory side, regulators support agriculture in coping with climate, market, and disaster shocks through risk identification, capital guidance, insurance-system development, disasterfinancing mechanisms, information disclosure, and stress testing. Financial regulators have begun treating agriculture-related climate risks (soil degradation, droughts, floods) as systemic financial risks. Globally, major regulators now recognize climate risks in the food and land-use sectors as threats to financial stability. Soil degradation alone causes USD 400 billion in economic losses annually, directly affecting agricultural asset values and credit risk[35].

Development finance institutions,especially the Agricultural Development Bank of China and the China

[33] World Bank. PPP Knowledge Lab – What is a Public-Private Partnership (PPP) Public-Private Partnerships (PPP) Resource Center. Available at: https://ppp.worldbank.org/

[34] The interest rate on central bank re-lending facilities is generally set below market levels; for instance, the PBOC's Agricultural Re-lending Facility ( 支农再贷款 ) typically carries a preferential rate.

[35] Sustainability Directory. "Financial Regulators Now See Soil Health as a Global Economic Stability Risk." Available at: https://news.sustainability-directory.com/food/financial-regulators-now-see-soil-health-as-a-global-economic-stability-risk/

Development Bank,play a unique role in supporting food-system resilience. They provide medium and long-term loans for resilience capacity building and sustainable development, can lead or participate in establishing food-system resilience funds, and can develop agricultural valuechain finance products to support storage, processing, import–export, and bank–insurance cooperation.

## 5.5 Key Findings and Policy Recommendations

### 5.5.1 Key Findings

Financial and fiscal instruments can support the strengthening of food-system resilience through capacity building and risk prevention, risk response and recovery, and resource allocation and sustainable development. Some financing-related policy tools,such as government funds, public–private resilience funds, and green funds,also play an active role in enhancing food-system resilience.

First, financial instruments use market mechanisms to diversify and transfer the complex risks faced by the food system. Among the various financial tools that enhance food-system resilience, insurance instruments play a unique role in risk response and production recovery. Medium-and long-term loans and development-finance loans are often used to support capacity building and sustainable development; transformational financial tools, including green finance and blended finance, can support multiple resilience functions. Different financial and policy tools can be used in combination to strengthen food-system resilience.

Second, public funding plays an irreplaceable role in financial support for food-system resilience. Many financial tools contain grant components. Agricultural-insurance premiums largely rely on government fiscal subsidies. Resilience funds for the food system are closely tied to fiscal inputs. Increasing subsidies for financial products and institutions that support food-system resilience reflects both WTO compliance requirements and the fact that subsidizing financial products and institutions may be more efficient than direct subsidies to farmers and enterprises, as they better leverage market mechanisms and mobilize more social resources for resilience building[36].

Third, blended finance is playing an increasingly important role in strengthening food-system resilience. Government fiscal funds and other grants can effectively mobilize private and social capital. Government investment can guide deposits and other social capital toward building a resilient food system, amplifying the impact of public funds; meanwhile, it requires that public funds and grants align with market-based operations. International organizations, such as the World Bank, ADB, UN agencies, the Gates Foundation, the World Resources Institute, and MOOSE,can provide grants for platform building, knowledge sharing, and resilienceagriculture pilots.

Fourth, national financial policy, central-bank monetary tools, and financial regulation are crucial for leveraging financial instruments to support food-system resilience. Central banks and regulators can use targeted relending, interest subsidies, specialpurpose bonds, and asset securitization to encourage financial institutions to support food-system resilience. Regulatory frameworks can also encourage innovative financial products, bank–insurance cooperation, and the development of blended finance.

### 5.5.2 Policy Recommendations

Fiscal and financial policies play foundational and guiding roles in food-system resilience building. A coordinated fiscal–financial approach should be used to create a diversified investment landscape of fiscal guidance, financial leadership, and social participation. To address current challenges,such as insufficient leverage of public funds, underdeveloped market-based resilience-financing mechanisms, and weak innovation capacity in resilience-oriented financial products,the following recommendations are proposed:

**(1) Strengthen the government's leading role in coordinating fiscal and financial tools for food-system resilience**

Increase government support for financial instruments that enhance food-system resilience.

[36] The proposition that subsidising financial products and institutions yields greater efficiency than direct subsidies to farmers and enterprises remains largely theoretical. Further empirical and case study research is required to substantiate this claim.

Encourage development-finance institutions,especially the Agricultural Development Bank of China and the China Development Bank,to expand support for resilience building. Central and local governments should prioritize blended-finance approaches to mobilize social capital. Local governments may establish guarantee funds or risk-compensation funds to support local banks and insurers in financing resilience initiatives.

(2) Encourage financial institutions to actively participate in resilience building and improve the regulatory framework for resilience finance

Incorporate food-system resilience into the central bank's and regulators' green-finance or inclusive-finance frameworks. Pilot low-interest relending facilities dedicated to food-system resilience, supporting processing, storage, logistics, and trade. Support agricultural and food enterprises in issuing resilience bonds and developing asset-securitization products. Allow and encourage banks, insurers, and non-bank financial institutions to innovate financial products for resilience. Include food-system resilience more explicitly in green-finance standards. Under specific conditions (e.g., extreme weather, major price shocks), regulators may allow higher tolerance for non-performing loans related to resilience-building investments.

(3) Deepen international resource integration to expand resilience-building channels and support precise policy and product optimization

Development-finance institutions may establish food-system resilience funds, used alongside loans and other financial tools. Commercial banks should strengthen empirical research to support evidence-based policy and product design. Insurers and other financial institutions should innovate products and expand international cooperation. China should connect with global climate-finance mechanisms (e.g., GCF, GAF), participate in cross-border agricultural-risk-sharing mechanisms, and promote mutual recognition of cross-border resilience-finance standards. Given China's extensive pilots and applications of resilience-finance tools, researchers should be encouraged to conduct empirical studies,leveraging AI where appropriate,to support policy design and financial-tool innovation.

**References**


Cole S A, Giné X, Tobacman J, et al. Barriers to household risk management: Evidence from India[J]. American Economic Journal: Applied Economics, 2013, 5(1): 104–135.

Lane G. Emergency loans promote climate change adaptation and can be profitable for microfinance institutions[EB/OL]. VoxDev, 2024 [2026-05-27]. https://voxdev.org/topic/finance/emergency-loans-promote-climate-change-adaptation-and-can-be-profitable-microfinance-institutions.

BCG. Building Resilience in Agrifood Supply Chains[R]. Boston: Boston Consulting Group, 2022.

Food and Agriculture Organization of the United Nations. Increasing the Resilience of Agricultural Supply Chains[R]. Rome: FAO, 2021.

United Nations Development Programme. Financial Resilience in Agriculture[R]. New York: UNDP, 2021.

IPES-FOOD. From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems[R]. International Panel of Experts on Sustainable Food Systems, 2016.

IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change[R]. Geneva: IPCC, 2014.

OECD. Food Supply Chains and COVID-19: Impacts and Policy Lessons[EB/OL]. 2020-06-02 [2026-01-14]. https://www.oecd.org/coronavirus/policy-responses/food-supply-chains-and-covid-19-impacts-and-policy-lessons-71b57aea.

Abdul Latif Jameel Poverty Action Lab. Microcredit: Impacts and Limitations[EB/OL]. https://www.povertyactionlab.org/sites/default/files/Microcredit%20impacts%20and%20limitations_1.pdf.

World Bank. China: Innovations in Agricultural Insurance. Promoting Access to Agricultural Insurance for Small Farmers[R]. Washington, DC: World Bank, 2007.

Food and Agriculture Organization of the United Nations. Agricultural Insurance in Asia and the Pacific Region[R]. Bangkok: FAO Regional Office for Asia and the Pacific, 2011.

Hazell P, Poulton C, Wiggins S, et al. The future of small farms: Trajectories and policy priorities[J]. World Development, 2010, 38(10): 1349–1361.

Glauber J W. The growth of the federal crop insurance program, 1990–2011[J]. American Journal of Agricultural Economics, 2013, 95(2): 482–488.

Skees J R, Enkh-Amgalan A. Examining the Feasibility of Livestock Insurance in Mongolia[R]. Washington, DC: World Bank, 2002.

Turvey C G. Whole Farm Income Insurance in a Canadian

Context[C/OL]. Working Paper, 2010-05-03 [2026-01-14]. https://ssrn.com/abstract=1603209.

Aon. ILS Annual Report for the Peril from July 1, 2024 to June 30, 2025[R]. London: Aon, 2025.

Coble K H, Barnett B J. Why do we subsidize crop insurance?[J]. American Journal of Agricultural Economics, 2013, 95(2): 498–504.

Gonulal S O, Goulder N, Lester R. Bancassurance: A Valuable Tool for Developing Insurance in Emerging Markets[R]. Policy Research Working Paper Series 6196. Washington, DC: The World Bank, 2012.

Hodge G A, Greve C. Public-private partnerships: An international performance review[J]. Public Administration Review, 2007, 67(4): 545–558.

Fang R, An Y, Liu W. Can the "insurance + futures" pilot improve farmers' grain-growing incentives? , An analysis based on the mediating effect of farmers' willingness to participate and the moderating effect of satisfaction with government subsidies[J]. Chinese Rural Economy, 2019(6): 2–15.

Bei D, Xing L. Inclusive Insurance Ready to Launch[M]. Beijing: China Financial Publishing House, 2025.

Liu Y. Comparison and analysis of the utilization degree of futures markets by Chinese and American farmers[J]. Research on Financial and Economic Issues, 2008(5): 59–66.

Chen Z, Zhan Y, Zhang Y, et al. The impact of the COVID-19 pandemic on global food security and countermeasures[J]. Chinese Rural Economy, 2020(5): 1–11.

Li Y, Sun R. Agricultural product futures price insurance and its role in price mechanism reform[J]. Insurance Studies, 2017(3): 90–102.

Li Z, Zhao L. Research report on the development of China's "insurance + futures" model(2023)[J]. Insurance Theory and Practice, 2023(12): 40–59.

Zhou X. Food is the first necessity of the people: A literature review on agricultural insurance research[J]. Insurance Studies, 2010(5): 119–127.

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