

The Impact Mechanism of Digital Technology on Food Security in the Transformation of Green Agriculture

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Abstract: Against the backdrop of green agriculture transformation, digital technology has become an important force in promoting high-quality agricultural development and ensuring food security. This article analyzes the mechanism of the impact of digital technology on food security, and explores the inherent logic of digital technology empowering food security from the aspects of improving agricultural production efficiency, optimizing resource allocation, strengthening risk management, and upgrading the industrial chain. Research suggests that digital technology can enhance the efficiency of agricultural factor allocation, promote the transformation of green production methods, improve the operation mechanism of the grain market, and improve the capacity and security level of grain supply. At the same time, digital technology provides economic support for sustainable agricultural development, which helps to achieve the coordinated promotion of green agriculture transformation and food security.

1. Introduction

Food security is an important foundation for national economic stability and social development. Against the backdrop of increased resource and environmental constraints, rising agricultural production costs, and intensified global climate change impacts, traditional agricultural development models face difficulties in improving production efficiency and pressure for sustainable development. The transformation of green agriculture has become an important direction for promoting high-quality agricultural development, with its core being the coordination and unity of resource conservation, environmental friendliness, and food supply capacity improvement through innovative production methods^[1]. At the same time, the rapid development of digital technology has provided new technological support for the transformation of agricultural production methods and food security. Digital technology can optimize agricultural resource allocation, improve production efficiency, enhance agricultural risk response capabilities, and promote the coordinated development of the grain industry chain through data element empowerment, intelligent management, and information resource integration. Therefore, in-depth analysis of the mechanism and economic effects of digital technology on food security in the transformation of green agriculture is of great theoretical significance and practical value for understanding the digital empowerment of agricultural modernization development and improving the food security guarantee system.

2. Theoretical basis for the impact of digital technology on food security in the transformation of green agriculture

2.1 The Logic of the Role of Digital Technology in Empowering the Transformation of Green Agriculture

The core of digital technology empowering the transformation of green agriculture lies in reconstructing agricultural production methods through data elements and intelligent tools, improving the efficiency of agricultural resource utilization and production management level. On the one hand, digital technology relies on the Internet of Things, big data, artificial intelligence and other means to achieve precise perception, dynamic monitoring and scientific decision-making in the agricultural production process, promote the transformation of agriculture from experience driven to data-driven, and reduce resource waste in the production process. On the other hand, digital technology promotes the optimal allocation of agricultural production factors, by improving the matching efficiency of factors such as capital, land, and labor, and enhancing the level of intensification and greening of agricultural production^[2]. In the process of green agriculture transformation, digital technology not only improves agricultural production efficiency, but also provides technical support for the stability and sustainability of food production, forming a mechanism for promoting agricultural green development through technological innovation.

2.2 The intrinsic requirements of green agriculture transformation for ensuring food security

Under the background of green agriculture transformation, food security has shifted from simply pursuing yield growth to a comprehensive goal that balances supply stability, resource sustainability, and ecological security. The traditional agricultural production model is highly dependent on resource input, and while improving food output, it also faces issues such as increased resource constraints and ecological pressure, making it difficult to meet long-term food security needs^[3]. Therefore, the transformation of green agriculture requires improving the efficiency of agricultural resource utilization through changes in production methods, and achieving coordination and unity between food production capacity and ecological protection. At the same time, the development of green agriculture requires strengthening the ability to prevent and control agricultural risks, and improving the adaptability of the agricultural system to uncertain factors such as climate change and market fluctuations. In this process, digital technology has become an important supporting force for promoting agricultural green transformation and ensuring food security.

2.3 Theoretical analysis framework for the coordinated development of digital technology and food security

The theoretical logic of the coordinated development of digital technology and food security is mainly reflected in three levels: technological empowerment, factor optimization, and system improvement(Figure 1). Firstly, digital technology enhances the informatization level of agricultural production processes, promotes the improvement of agricultural production efficiency, strengthens food supply capacity, and provides a basic guarantee for food security. Secondly, digital technology optimizes the allocation of agricultural resources, promotes the flow of agricultural production factors towards high efficiency and low consumption, and achieves the coordination and unity of green agriculture development and grain production goals. Finally, digital technology enhances the stability and resilience of the food security system by improving the agricultural information service system, improving the synergy of the industrial chain, and enhancing the level of risk warning. This forms an internal chain of "digital technology driven - green agriculture transformation - food

security improvement", providing a theoretical basis for analyzing the coordinated development of the two.

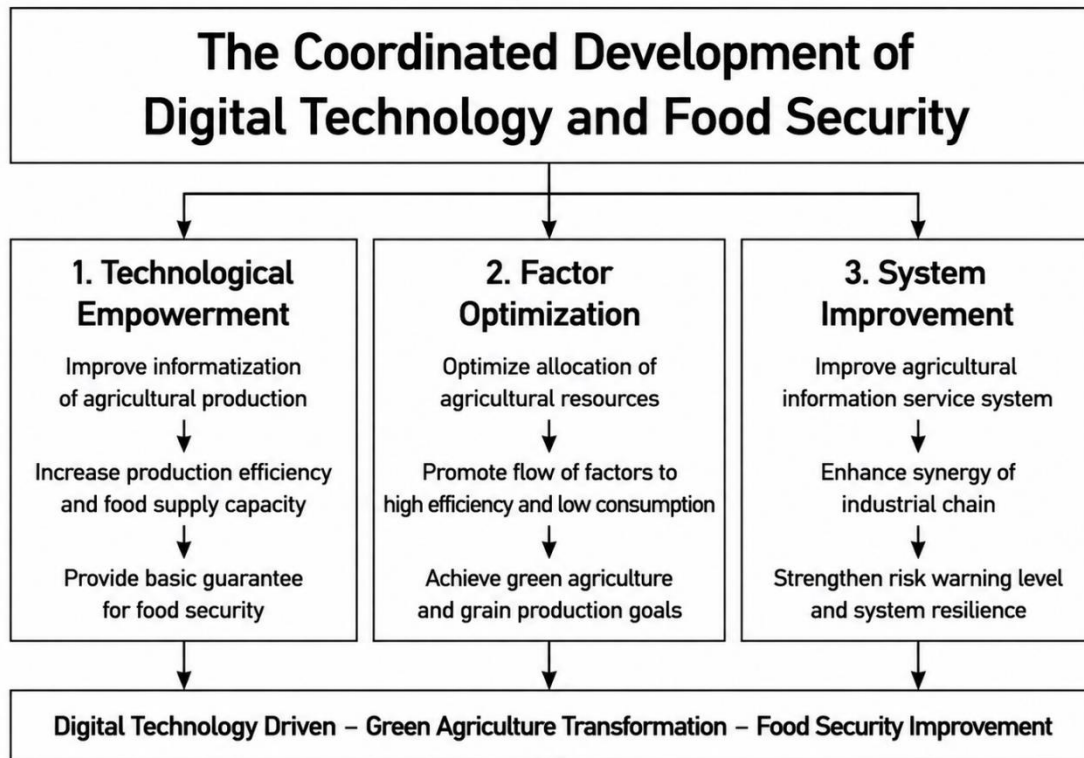


Figure 1: Theoretical Framework for the Coordinated Development of Digital Technology and Food Security

3. The Mechanism of the Impact of Digital Technology on Food Security

3.1 Digital technology enhances agricultural production efficiency and food supply capacity

Digital technology improves agricultural production efficiency and enhances food supply capacity by promoting precision, intelligence, and informatization in the agricultural production process. In the traditional agricultural production mode, production decisions mainly rely on the experience of farmers, which is easily affected by factors such as information asymmetry, insufficient resource input, and changes in natural conditions, leading to limited improvement in agricultural production efficiency^[4]. The application of digital technology can achieve dynamic monitoring of farmland environment, crop growth status, and production factor inputs through data collection, intelligent analysis, and precise management, helping agricultural operators develop more scientific and reasonable production plans. At the same time, digital technology promotes the integration of agricultural mechanization and intelligence, improves the automation level of agricultural production processes, reduces labor costs, and enhances the output efficiency of unit land resources. From an economic perspective, digital technology promotes the transformation of grain production from extensive growth to intensive and efficient growth by enhancing agricultural total factor productivity. In addition, digital technology can promote the rapid dissemination of agricultural knowledge, technology, and information resources, improve the ability of agricultural operators to obtain market information and production technology, thereby enhancing the stability of the food supply system and providing sustained impetus for food security.

3.2 Digital Technology Promotes Resource Optimization and Green Grain Production

Digital technology promotes the optimal allocation of agricultural resources and is an important mechanism for promoting the transformation of green agriculture and ensuring food security. In the process of agricultural production, the input efficiency of production factors such as land, water resources, fertilizers, and pesticides directly affects the cost of food production and ecological sustainability. Digital technology achieves effective matching between production resource input and crop demand through precise analysis of agricultural production data, reducing excessive use and ineffective input of resources, and improving the efficiency of agricultural resource utilization^[5]. For example, the precision agriculture management model based on data analysis can adjust production inputs according to soil conditions, climate conditions, and crop growth needs, achieving refined management of the agricultural production process^[6]. In economic terms, digital technology reduces resource waste and environmental governance costs in agricultural production, and improves the economic benefits of green agricultural production. At the same time, digital technology is driving the transformation of agricultural production models from high input and high consumption development modes to resource-saving and environmentally friendly modes, achieving coordinated development between increased grain production and ecological protection. Therefore, digital technology not only improves the efficiency of food production, but also provides a resource foundation for the long-term stability of food security by promoting the formation of green production methods.

3.3 Digital technology strengthens agricultural risk management and food security resilience

Digital technology enhances the resilience of the food security system by improving the ability to identify, warn, and respond to agricultural risks. In the process of agricultural production, factors such as natural disasters, climate change, market fluctuations, and supply chain instability may all have an impact on food security. Traditional risk management methods are difficult to respond to complex and changing agricultural risks in a timely manner due to lagging information acquisition and limited predictive capabilities^[7]. Digital technology relies on big data analysis, intelligent prediction, and information sharing platforms to dynamically monitor agricultural production environment, market supply and demand changes, and disaster risks, improving risk prediction and emergency management capabilities. On the one hand, digital technology can help agricultural entities adjust production strategies in advance and reduce the impact of natural factors on grain production; On the other hand, digital information systems can strengthen the information linkage between the government, enterprises, and farmers, and improve the coordination ability of the grain production and circulation system. From an economic perspective, digital technology has reduced the uncertainty of agricultural production, minimized economic losses caused by risks, and improved the ability of agricultural systems to withstand external shocks. By enhancing the level of agricultural risk management, digital technology further improves the stability and sustainability of the food security system.

3.4 Digital technology promotes the upgrading of the agricultural industry chain and the improvement of the food security guarantee system

Digital technology promotes the digital integration of various links in the agricultural industry chain, promotes the upgrading of the agricultural industry system, and further improves the food security guarantee system. Food security depends not only on the production process, but also on the joint influence of processing, circulation, storage, and consumption. In the traditional agricultural industry chain, the efficiency of information transmission between various links is low,

which easily leads to problems such as insufficient supply and demand matching, high circulation costs, and insufficient market regulation capabilities^[8]. Digital technology strengthens the information connection between production, processing, transportation, and sales links by building agricultural information platforms and intelligent management systems, thereby improving the operational efficiency of the agricultural industry chain. In the field of grain production, digital platforms can promote the connection between production and sales, optimize the allocation of grain resources, reduce losses in the circulation process, and improve market operation efficiency. At the same time, digital technology promotes innovation in agricultural industry organizational models, facilitating the formation of closer interest linkage mechanisms between agricultural enterprises, cooperative organizations, and farmers. From the perspective of economic development, digital technology has enhanced the value creation capability of the agricultural industry chain, strengthened the competitiveness and stability of the grain industry system. By upgrading the industrial chain and utilizing digital technology, the scope of food security has been further expanded, achieving an extension from production safety to industrial system safety.

4. Case analysis of digital agriculture in Heilongjiang Province

As the largest commodity grain production base in China and the cornerstone of national food security, Heilongjiang Province has continuously promoted the construction of digital agriculture in recent years, widely applying digital technologies such as the Internet of Things, big data, Beidou navigation, and artificial intelligence to the entire process of grain production. Relying on modern agricultural management entities such as Beidahuang Group, Heilongjiang continuously improves the construction of smart farms and promotes the intelligent upgrading of farming, planting, management, and harvesting processes. With the support of digital technology, the intelligent agricultural machinery equipped with the Beidou navigation system can control the operation accuracy within ± 2.5 centimeters. The unmanned aerial vehicle patrol, remote sensing monitoring, and agricultural big data platform have achieved real-time monitoring of crop growth status, soil moisture, and pests and diseases, providing data support for scientific planting and precise management. At the same time, the province actively builds a model area for smart agriculture, promotes the deep integration of digital technology and green agriculture, and continuously improves the modernization level of grain production.

The development of digital agriculture has effectively improved the efficiency of grain production and the ability to ensure food security in Heilongjiang. By 2025, the total number of intelligent and efficient crop protection drones in the province will reach 33000, the number of agricultural machinery operation monitoring terminals will reach 121800, the cumulative area of aerial operations will reach 700 million mu, and the application area of integrated water and fertilizer technology in dry fields will reach 4.007 million mu, providing important support for cost saving, efficiency improvement, and green production in agriculture. At the same time, the total grain output in Heilongjiang Province will reach 164.06 billion catties by 2025, stabilizing at over 160 billion catties for two consecutive years. A total of 125 million acres of high standard farmland will be built, and the comprehensive mechanization rate of crop cultivation and harvesting will remain above 99%, ranking among the top in the country^[9]. Practice has shown that digital technology provides a typical demonstration and practical basis for ensuring national food security in the context of green agriculture transformation by improving the efficiency of agricultural resource allocation, enhancing risk monitoring and early warning capabilities, reducing production costs, and optimizing the operation of the grain industry chain.

5. Economic Analysis of the Impact of Digital Technology on Food Security in the Context of Green Agriculture Transformation

5.1 Economic effects of digital technology driving the efficiency improvement of agricultural factor allocation

Digital technology improves the efficiency of agricultural production factor allocation, promotes the flow of agricultural resources to high-efficiency areas, and thus generates significant economic effects. Under the traditional agricultural development model, there are problems of insufficient information and inefficient matching among factors such as land, labor, capital, and technology, which can easily lead to a mismatch between resource input and agricultural production demand. Digital technology improves the ability of production entities to obtain resource status, market demand, and technological conditions by building agricultural data platforms and information service systems, promoting more accurate allocation of agricultural factors. At the same time, digital technology can reduce the information search and transaction costs in agricultural production, improve the decision-making efficiency of agricultural management entities, and promote the transformation of agricultural production from extensive input to refined management. From the perspective of economic development, improving the efficiency of factor allocation helps to increase agricultural total factor productivity, reduce food production costs, enhance agricultural industry competitiveness, and further improve food supply capacity, providing a stable economic foundation for food security.

5.2 Economic effects of digital technology promoting the transformation of green production methods in agriculture

Digital technology promotes the transformation of green agricultural production methods, which not only helps to reduce agricultural ecological costs, but also creates new economic growth drivers. In the process of agricultural production, excessive resource input and increased environmental pressure can affect the long-term benefits of agricultural development. Digital technology can optimize the agricultural production process through precise monitoring and intelligent management, reduce inputs such as fertilizers, pesticides, and water resources, and improve resource utilization efficiency. The formation of green production methods can reduce environmental governance costs in agricultural production processes, enhance agricultural ecological value, and achieve the unity of economic and ecological benefits. At the same time, digital technology promotes the standardized development of green agriculture, improves the quality and market recognition of agricultural products, and enhances the market competitiveness of green food products. From an economic perspective, digital technology promotes the green transformation of agriculture, helping to improve the structure of agricultural production income, enhance the added value of the agricultural industry, and create a more stable development environment for sustainable food security by reducing resource consumption and ecological risks.

5.3 Economic effects of digital technology improving the operation mechanism of the grain market

Digital technology improves the efficiency of information flow in the grain market, optimizes market operation mechanisms, and enhances the ability to regulate grain supply and demand. In traditional grain markets, due to information asymmetry between producers and consumers, it is easy to cause problems such as delayed market signal transmission, price fluctuations, and insufficient resource allocation efficiency. Digital technology, relying on big data analysis,

information sharing platforms, and intelligent prediction systems, can strengthen the information connection between grain production, circulation, and consumption, and improve market entities' ability to judge changes in supply and demand. On the one hand, digital technology reduces market transaction costs and promotes more effective flow of food resources between different regions and entities; On the other hand, digital information systems can enhance the regulatory and control capabilities of the grain market, and strengthen the government's ability to predict food security risks. From an economic perspective, digital technology can help create a more transparent, efficient, and stable food market environment, reduce the impact of market fluctuations on food supply, and improve the operational efficiency of the food security system.

5.4 Economic effects of digital technology empowering sustainable agricultural development and long-term food security guarantee

Digital technology empowers sustainable agricultural development, providing economic support for long-term food security by promoting the improvement of agricultural production efficiency, optimizing industrial structure, and transforming development models. From a long-term development perspective, food security not only requires meeting the current demand for food supply, but also ensuring that the agricultural production system has the ability for sustainable development. Digital technology can promote innovation in agricultural production methods, improve the efficiency of agricultural resource utilization, and enhance the adaptability of the agricultural industry system. At the same time, digital technology promotes the integrated development of agricultural industry, promotes the deep integration of agriculture with information technology, modern service industry and other fields, expands the growth space of agricultural economy, and improves the comprehensive benefits of agricultural development. In addition, the digital governance system can enhance agricultural policy regulation and resource management capabilities, providing more accurate information support for the implementation of food security strategies. Therefore, digital technology promotes the transformation of agricultural economic growth mode, achieves the coordinated improvement of agricultural development efficiency, ecological protection ability, and food security ability, and provides important guarantees for long-term stability of food security.

6. Conclusion

Under the background of green agriculture transformation, digital technology has become an important driving force for improving food security. This article analyzes from three levels: theoretical basis, mechanism of action, and economic effects, and finds that digital technology promotes the improvement of food supply capacity and green development of agriculture by improving agricultural production efficiency, optimizing resource allocation, strengthening risk management, and promoting industrial chain upgrading. Meanwhile, digital technology plays an important role in reducing production costs, improving market operation mechanisms, and enhancing sustainable agricultural development capabilities, providing long-term economic support for food security. In the future, we should further promote the deep integration of digital technology and agricultural production system, improve the construction of digital agricultural infrastructure, enhance the digital governance capacity of agriculture, and achieve the coordinated development of green agriculture transformation and food security guarantee.

References

[1] Han Guanghe, Rao Shengnan. *Effect and Heterogeneity Analysis of Digital Technology Empowering the Resilience*

- of Grain Supply Chains[J]. *Modern Agricultural Science and Technology*, 2026,(4):191-195.
- [2] Xia Xin, Li Jianming, Zhang Rui. The Mechanism and Implementation Path of Digital Technology Empowering Food Security[J]. *Agricultural Economy*, 2025,(8):29-31.
- [3] Han Ji. Risk Identification and Mitigation Strategies of Digital Technology Driving Global Food Security Governance in the Digital Era[J]. *Journal of Beihua University (Social Sciences)*, 2025,26(4):91-101+154.
- [4] Han Ji. Reshaping Grain Supply Chains in the Digital Era and China's Food Security Guarantee[J]. *Journal of Southwest University of Science and Technology (Philosophy and Social Science Edition)*, 2024,41(4):43-52.
- [5] Xiao Xiangxiong, Guo Sufang, Teng Junlei. Theoretical Logic and Optimization Paths of Digital Technology Empowering National Food Security Governance[J]. *Modern Agriculture*, 2023,48(5):82-86+90.
- [6] Cui, S. (2026). Can Digital Village Construction Safeguard Food Security? Mechanisms and Empirical Evidence. *Hubei Agricultural Sciences*, 65(1), 211–219.
- [7] Ma, J., & Li, G. (2025). Digital Technology Empowering National Food Security Governance: A Perspective Based on Central–Local Government Relations. *Rural Economy*, (4), 42–50.
- [8] Peng, J., & Huang, S. (2024). The Mechanism of Digital Technology's Impact on Grain Yield from the Perspective of Food Security. *Journal of South China Agricultural University (Social Science Edition)*, 23(4), 77–92.
- [9] Liu, J., Liu, X., & Liu, Q. (2023). Research on Innovative Measures for Food Security Assurance in Pingliang City through Digital Technology. *Agricultural Science and Technology & Information*, (10), 35–38.