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Original Paper

Digital Technology Enabling High-quality Development of the Whole Agricultural Chain in Chongqing Path Study

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Abstract

This study examines the current state of agricultural digitalization in Chongqing from three perspectives: technology, policy, and market environment. It explores the mechanisms through which digital technologies drive high-quality development across the entire agricultural industry chain, while also identifying existing challenges. By comparing the digital transformation pathways of agriculture in the European Union, the United States, and Japan, the study proposes a development framework that emphasizes region-wide digital collaboration, the establishment of a digital farmer training system, and the promotion of agricultural production trustee services. Furthermore, it highlights the role of real-time feedback mechanisms in refining the integration of digital technologies to enhance the quality and sustainability of agricultural development.

Keywords

Digital Chongqing, High-Quality Agricultural Development, Whole-Industry Chain

In recent years, with the rapid development of digital technology, the agricultural digitization of Chongqing has significantly accelerated. Chongqing has completed the construction of digital information infrastructure, digital agricultural innovation bases, and laboratories, and has achieved remarkable results in the integration of the entire agricultural industry chain. Following the “Seven Modernizations” construction task in 2021, Chongqing proposed the “13432” work deployment to further promote agricultural modernization in November 2023. However, while rapidly advancing agricultural development, we should focus more on the efficient use of resources and environmental protection to ensure the high-quality and sustainable development of agriculture.

1. Foundations of Development

1.1 Technological Advancement

Digital technology empowers the high-quality development of the whole agricultural industry chain, strengthens the deep mining of data and green development, and of the whole agricultural industry chain with digital technology deeply integrates. The continuous development of digital technology has made this new development model increasingly perfect, and the production efficiency of agricultural products, business methods, management methods and so on have been significantly improved and

upgraded. From the viewpoint of the agricultural industrial system, the empowerment of digital technology the three major links (pre-production-production-post-production) has realized the extension and of the expansion agricultural industry chain and value chain, and promoted the pace of integration and digitalization of and process modernization the agricultural industrial system.

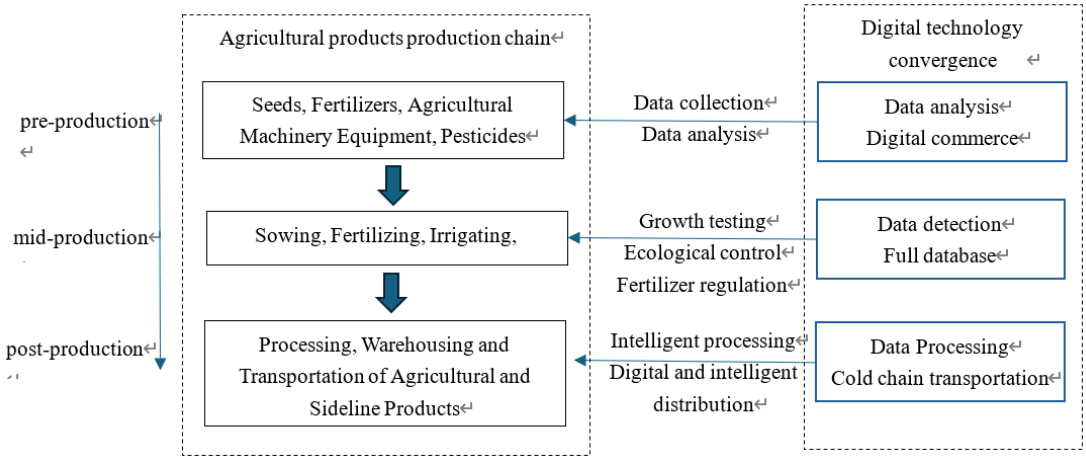

Figure 1. Digital Technology Empowers the Path of the Whole Agricultural Industry Chain

In the "pre-production" part of the agricultural industry chain, Chongqing has accelerated the establishment of data collection and data analysis systems. 2024, Chongqing has four cases selected as national-level, and it has created the cases of intelligent agriculture construction, including the "Nongpinhui" platform, the intelligent farm machinery of Fuxi Farm in Changshou District, the intelligent fish catching/stopping by Gansen Electronic Technology, and the "Fuhui Nutrition" intelligent breeding for common prosperity. As of December 2023, Chongqing has created "Yu Nong Brain", secured approval for six national-level digital agriculture innovation and application base projects, established seven single-variety full-industry-chain digital information systems, and built 574 intelligent agriculture bases. Based on Chongqing's complex climate and terrain, it has developed agricultural digital core technologies, established farm remote-sensing monitoring systems and citrus unmanned farms. In 2023, it completed the construction of "Blockchain + Agriculture" and "5G + Smart Agriculture" innovation and application laboratories. It first realized unmanned agricultural machinery autonomous driving technology in hilly and mountainous areas, and succeeded in remotely controlling farm machinery operations such as plowing and sowing. It also completed the national Chongqing (Rongchang) Swine Big Data Center, with the platform having 160,000 transaction users nationwide by 2023, a total transaction value of 110 billion yuan, and a cumulative transaction volume of over 85 million pigs. Additionally, it innovatively established new agricultural models such as "fish-vegetable symbiosis AI factories", smart rice fields, seedling factories, and smart orchards (Note 1). It is expected that by 2025, Chongqing will have built 60 pilot demonstration bases for smart agriculture.

1.2 Policy Implementation

In recent years, to promote the high-quality development of agricultural modernization in Chongqing, the municipal government has issued a series of policy documents in line with local characteristics, mapped out a timeline and roadmap for the digital development of agriculture and rural areas across the city, implemented the action of cultivating 100 billion-level advantageous and distinctive industries, focused on developing the "3+6+X" agricultural industrial cluster, and proposed to speed up the modernization of Chongqing's rural areas.

Recently, the municipal government has popularized and implemented documents like the "Chongqing Smart Agriculture Development Implementation Plan (Trial)", the "14th Five-Year Plan for the Development of Digital Agriculture and Rural Areas in Chongqing", the "Chongqing Digital Village Development Action Plan (2020-2025)", and the "Chongqing Innovation-driven Development Strategy Action Plan Led by Big Data and Intelligence (2018-2020)". Five districts and counties in Chongqing, namely Yubei, Banan, Dianjiang, Rongchang, and Dazu, have been selected as the first - batch national digital village pilot areas. Leveraging advanced technologies such as the Internet of Things, cloud computing, and blockchain, the municipal government is promoting the digital management of rural collective economy, assets, and property rights transactions. By encouraging new-type agricultural business entities to participate in the construction and application of digital agriculture, the government has laid a policy foundation for the digital transformation of traditional agriculture, improving agricultural production efficiency and quality, and promoting farmers' income increase and rural revitalization.

1.3 Market Maturity

The Chongqing government, by partnering more closely with internet platforms, integrating local specialty farming and livestock products, and reinforcing digital infrastructure, has improved the efficiency of post-production agricultural processes. This has effectively boosted market transformation and the digital-economy dynamism in rural Chongqing.

In the post-production stage of the agricultural industry chain, Chongqing has set up big-data and brand-resource databases. It has also achieved much in the intelligent processing and distribution of agricultural products. In 2023, Chongqing built a big-data platform for agriculture, rural areas, and farmers. The platform has "seven single-variety big data" types, including for pigs, oranges, lemons, pickled vegetables, crisp plums, tea, and black sheep. Using a "2 + 1 + 2" structure, it has 830 resource entries, 4,874 data items, and over 80 million pieces of agricultural-related data. It has formed 11 data-analysis subjects. These subjects cover 135 indicators, 38 dimensions, and 55 presentation forms.

As of September 2023, over two years after the launch of Chongqing's agricultural-industry digital map, it had finished creating the city's first arable-land-plot distribution map. Using sub-meter high-resolution satellite images, it accurately extracted over 20 million plot-planting units. By January 2025, 18,721 companies had joined the "Agricultural Product Wisdom" platform, benefiting production and sales firms across Chongqing's 38 districts and counties. These included 50,850 growers and breeders, covering 3,128 agricultural-product types. It had facilitated 201,000 online and offline transactions, boosting farmers' income by over 5.914 billion yuan. The market's rapid growth has also propelled the development of Chongqing's agricultural and rural industry chain.

2. Challenges in Digital Empowerment

2.1 Weak Infrastructure and Digital Gaps

Chongqing's rural digitalization develops rapidly. Although leading in the west, its agricultural-production informatization level, calculated by valid data, still lags behind other Chinese cities. See Table 1 for details.

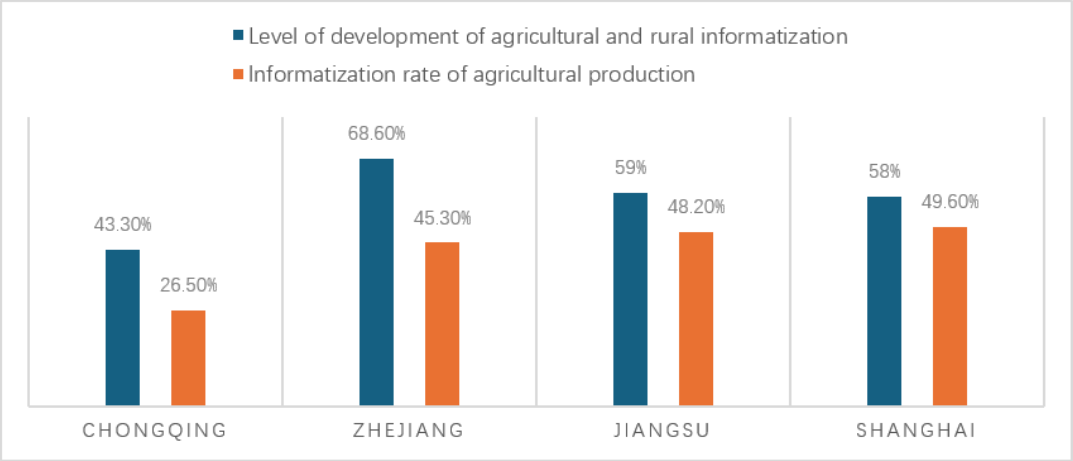

Figure 2. Overall Digital Development Level of Chongqing in 2022

In recent years, Chongqing has tackled network infrastructure delays in some districts due to geography and terrain. In 2023, 5G coverage reached 100% in all towns. However, there's no core data-construction support system yet. Scattered villages, limited software services, and lacking application-architecture foundations have caused many 4G/5G signal blind spots in agricultural bases. Rural informatization software promotion is challenging, with application depth lagging behind Jiangsu, Zhejiang, and Shanghai, and low informatization levels in agricultural production.

2.2 Limited Data Utilization and Innovation Capacity

At present, the mechanisms, systems, and top-level design for big-data construction in agriculture and rural areas across regions need enhancing. In agricultural application scenarios, insufficient data integration and sharing mean data isn't shared efficiently among enterprises, scenarios, and government departments. "Data silos" and "digital chimneys" remain unsolved in market links, hindering data and information sharing across the entire industry chain. The government needs to lead in designing a top-level architecture and promoting data integration and sharing.

Meanwhile, there's a lack of diverse digital-technology application scenarios, and data-application feedback mechanisms are incomplete. The value of data elements isn't fully utilized. Data isn't connected across the pre-production, mid-production, and post-production stages, with much data remaining "dormant" and not properly processed. The integration of digital technology with agricultural entities, production-circulation, and rural-property-rights resources isn't deep enough. Farmers' credit data is scattered, slowing financial support for agriculture. Information asymmetry exists in agricultural production and sales, preventing individual farmers from effectively connecting with markets and understanding demand, and no timely feedback mechanism has been formed.

2.3 Shortage of Digital Talent

Digital technology can boost the whole-industry-chain development of agriculture only with sufficient digital-tech talents. However, due to the insufficient in-depth application of digital technology, the high professionalism of both digital and agricultural production technology, digital-tech talents in agriculture and rural areas lack understanding of agricultural technology, while agricultural-technology talents find digital technology hard to learn. Moreover, the market's limited appeal of agricultural digitization leads to a huge talent gap.

The current agricultural workforce is aging with low education levels, making it hard to find talents with digital-tech backgrounds. This restrains the positive effect of the digital economy on agriculture's high-quality development. Therefore, enhancing digitization's appeal to talents and solving talent shortages for its high-quality development requires a sound talent-training system. Currently, core resources for digital-tech-empowered agricultural innovation are mostly in enterprises and research institutes. To improve training efficiency and quality, universities, enterprises, and research institutions need to collaborate on training key digital-agricultural-tech talents.

3. International Experiences

3.1 EU: Digital Integration and Data Collaboration

The EU has developed a diverse and collaborative digital strategy for agricultural growth, leveraging regional differences in agricultural and rural development. Initially, varying development levels among member states created significant digital barriers, hindering deep digital integration. To overcome this, the EU established a top-level framework to boost the efficient circulation of digital products and services among member states.

The EU has released a series of documents to set standards, creating a relatively safe and open data-standard model for multi-regional contexts. Policies like the "Digital Single Market Strategy", "Shaping Europe's Digital Future", and "European Data Strategy" have laid the groundwork for digital technology application in agriculture. The Smart Agrihubs and AgRoBofood projects are good examples. Smart Agrihubs connects digital innovation centers, universities, farms, etc., across the EU, involving five agricultural sectors and 28 flagship innovation experiments. AgRoBofood develops agricultural robots for different regions. These projects enhance digital technology application in EU agriculture, addressing aging populations and youth outflow.

3.2 US: Precision-Driven Industrial Chain Development

As a pioneer in digital villages and smart agriculture, the US has a high proportion of numerous family farms. Thus, "how to replace human labor and connect industrial and regional ties" is the focus of US agricultural reform. During this process, the US has achieved its goals from three aspects: agricultural database, talent cultivation, and e-commerce.

Initially, aiming to create free agricultural and rural research data resources, the US Department of Agriculture established the National Agricultural Library, which developed many open-shared agricultural databases and simulation systems. This formed a digital network covering different levels and departments. Later, data companies began focusing on digital agriculture. For instance, Farmeron launched a web-based farm management tool in 2011, enabling farmers to record livestock situations. By integrating fragmented production records and using advanced analysis tools, it generated targeted farm-monitoring and production-status reports. These reports helped farmers make scientific production plans. Solum, after securing new funding in 2012, achieved efficient and precise

soil-sampling analysis, boosting output and reducing fertilization costs. It helped farmers fertilize precisely at the right time and place.

Next, the US systematically promoted digital-talent cultivation through vocational and basic education. In vocational education, the US government allocated special funds to agricultural schools in 2013, improving farmers' production and management abilities. Vocational schools also developed teaching plans to support agricultural education. The US encouraged agricultural dealers to promote precision technologies such as fleet management and drone-based pesticide spraying. By 2023, 78% of US farm-machinery manufacturers had promoted these technologies to farmers, achieving intelligent mechanical-scene applications. In basic education, the US Department of Education connected IT with the education system, deployed digital-education tasks in rural areas, and proposed an education-informatization framework to improve education quality and talent cultivation.

Finally, the US developed a diverse e-commerce pattern, including farmer-to-customer connections, precision marketing, group buying, and loan financing. The Farmers Business Network (FBN) helped family farmers by providing data and technical support. It linked agricultural - technology developers and farmers through farm-trial networks, optimizing input projects and offering farmers the best returns. FBN Finance segment provides U.S. family farmers with a digital loan platform, regenerative agriculture financing, sustainability premiums, crop and livestock digital insurance platform, grain marketing and other functions, achieving comprehensive scenario application of the whole agricultural industry chain.

3.3 Japan: Technology-Driven Labor Substitution and the "Sixth Industry"

Unlike the US's large-scale agriculture, Japan, with its aging population and rural hollowing, is a small-scale farming nation. It proposed a strategy of trading technology for labor and competitiveness, and promoted the "Sixth Industry" philosophy.

The early "industrial integration model" integrated the "primary sector" + "secondary sector" + "tertiary sector", encouraging farmers to engage in whole-industry-chain production and operation, covering crop planting, processing, and sales. The "Sixth Industry" has extended the agricultural industry chain, forming a closely-integrated "1 + 2 + 3" industrial chain, which has invigorated agricultural development. This process has lengthened the Agricultural product industry and value chains, added value to Agricultural products, significantly increased farmers' income, narrowed urban-rural income gaps, and ensured farmers gain from the "Sixth Industry".

Later, Japan strengthened technology introduction and clarified social division of labor. It brought in advanced digital technologies and defined the professional division of agricultural production, encouraging regional and farmer-specific industrial characteristics. Based on localized foreign technologies, Japan promoted digital-technology application. For example, the 2019 launch of WAGRI, a national agricultural data-sharing platform, connected various agricultural data and services, offering comprehensive support to agribusinesses and farmers. Japanese farmers achieved data interconnection and collaboration via specialized production and shared platforms.

Finally, Japan reinforced policy support and focused on developing NGO functions. Recently, it accelerated digital-construction strategies with effective fiscal measures like tax cuts and subsidies, encouraging private-sector participation in smart agriculture. For instance, in 2015, Japan launched an agricultural-technology project integrating "smart machinery + smart IT"; in 2017, it implemented the "Future Investment Strategy" project, combining IoT, AI, big data, and robotics in agriculture; and in 2019, Japan's Ministry of Agriculture, Forestry and Fisheries has launched pilot programs nationwide

to test small drones and unmanned tractors in small-scale agricultural settings. Meanwhile, the NGO Japan Agricultural Cooperatives played a key role in organizing agricultural activities and distributing government subsidies, bridging the government and farmers to protect farmers' interests.

4. Strategies and Recommendations

4.1 Optimizing Digital Governance and Regional Coordination

First of all, the establishment of digital resource integration in the Chongqing region, breaking the digital barriers, to achieve cross-region, cross-departmental, cross-business digital synergistic development of the whole region, in the Chongqing Municipality has been established on the basis of the formation of the "3 + 6 + X" industrial digital brain, the expansion of the application of the "pre-production + postpartum" link of digital resource integration, forming a whole industry chain digital intelligence system.

Secondly, in order to ensure the coherence of the work of digital co-development, we should grasp the design of the top-level structure, pay attention to the implementation of work planning and co-operation and development issues in districts and counties, and co-ordinate the integration of resources between different districts and counties and different enterprises. For example, the competing conflicts and contradictions between different specialty agricultural products, and the development of specialty agricultural products while guaranteeing the digital empowerment and high-quality development of the whole industrial chain of basic agricultural products.

Finally, improve the risk early warning system of agricultural and rural industries, based on Chongqing's geographic and climatic characteristics, reduce the disaster losses of agricultural products in advance through the wind-absorbing prediction system, strengthen the cooperation with agricultural insurance companies, and reduce the risk of catastrophe with financial products.

4.2 Strengthening Talent Development and Digital Farmer Training

First, pay attention to the training of front-end innovative talents and establish a multi-dimensional talent cultivation system. At present, the age level of rural agricultural operators in China is generally distributed in a large number, and there is a serious lack of professional talents and composite professional talents to promote the high-quality development of digitalization. We can unite with universities in Chongqing, strengthen the role of vocational education, and build a platform for school-enterprise cooperation, including several agricultural science majors such as agronomy, plant protection, horticulture, and seed science with Southwest University, the College of Agronomy and Life Science of Chongqing University, the College of Life Science and Technology of Changjiang Teachers' College, the Three Gorges Vocational College of Chongqing, the Chongqing School of Agriculture, the Chongqing School of Agricultural Mechanization, and other higher education institutions and colleges. We will cooperate with other universities and colleges to cultivate agricultural professionals based on the market demand, which can not only cultivate high-end innovative scientific research talents, but also cultivate applied agricultural talents who can penetrate into the grassroots, and also allow enterprises to train and cultivate the practical operation of farmers in the reverse direction. Realize a multi-dimensional talent cultivation system.

Secondly, the digital farmer training mechanism is built with enterprises to efficiently cultivate practical talents. In the high-quality development of the digital-enabled agricultural industry chain, the most critical and fundamental is the farmer, through cooperation with enterprises, through short-term training, in the process of scenario-based application, to promote the farmers to master the digital

platform services, as well as intelligent mechanical facilities and equipment operation, and efficiently solve the problem of matching the supply side of the digital products and the demand side.

4.3 Promoting Digital Integration and Production Trustee Services

Strengthen the integration of digital technology in the entire agricultural industry chain and innovate the feedback mechanism for digital application. Establish a feedback mechanism oriented to the needs of production technology, promote the research and development of technology with obvious practical characteristics, improve the scenario of digital technology application through the feedback mechanism, improve the integration of digital technology and the agricultural industry in a result-oriented manner, and maximize the transformation efficiency and innovation efficiency of digital technology.

Firstly, in the pre-production segment, financial institutions are encouraged to improve the agricultural and rural credit system, which is more conducive to institutional risk assessment and credit decision-making, and to promote financial products such as 'Digital Intelligence Loan' as well as agricultural insurance products, so as to complete the upgrading of Chongqing's digital management of agricultural insurance, and to change from post-disaster claims settlement to risk reduction management in the whole production chain of agricultural production, and to establish a system of accurate pricing, rapid claims settlement and comprehensive insurance. It has also established accurate pricing, fast claims settlement and an all-round meteorological risk warning system to help the high-quality development of agricultural insurance in Chongqing.

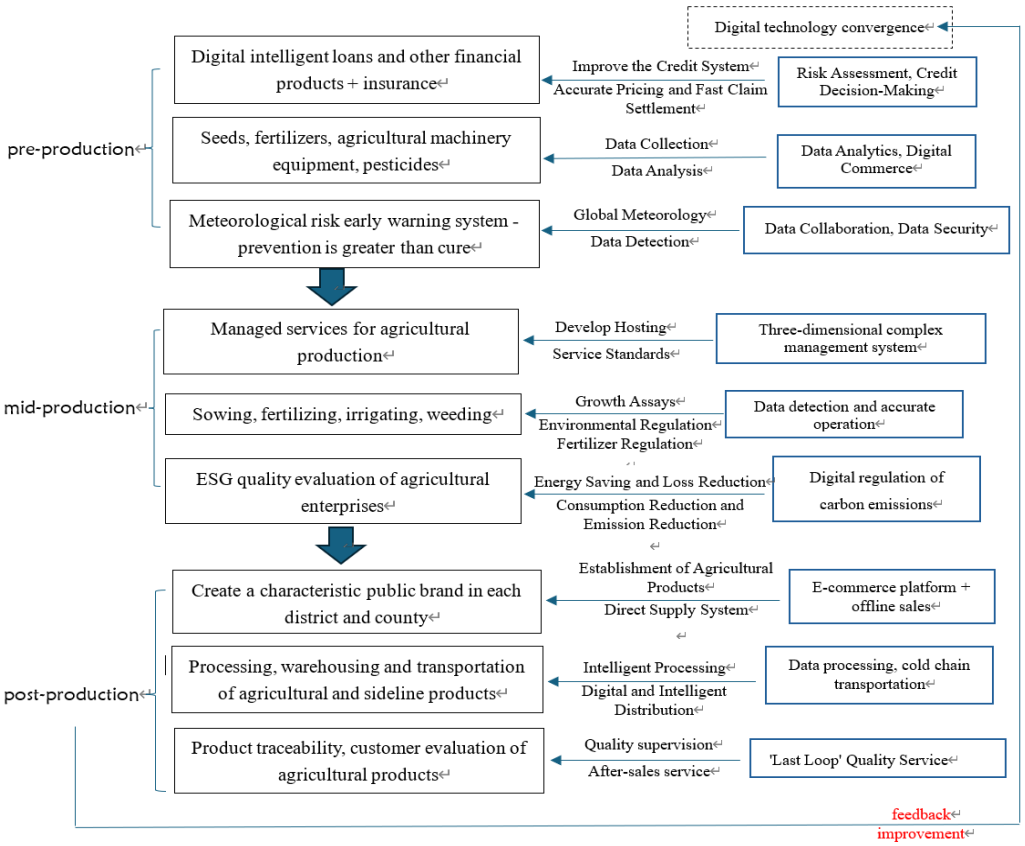

Figure 3. Expanded Development Path of Digital Technology-Enabled Agricultural Whole Industry Chain

Second, in the middle of the production chain, according to the complex terrain and landscape of Chongqing districts and counties, select appropriate areas to promote agricultural production hosting services. Agricultural production extension services can unite small farmers with the main parties providing production hosting services to build a platform of mutual cooperation, trust, supervision and win-win situation, and supervise the whole service process, including: contract signing, machine ploughing operations, technical guidance, data testing, supervision and acceptance, and many other aspects. At the same time, establish the ESG quality evaluation standard of agricultural enterprises in advance, pay attention to the energy saving and loss reduction, consumption reduction and emission reduction of the whole agricultural industry chain, play the role of Chongqing Carbon Emission Trading Centre, set up a digital system to supervise the carbon emission of agricultural enterprises, and achieve the green and sustainable development of agriculture in the Chongqing region.

Finally, in the post-production link, on the basis of the existing e-commerce platform + offline sales, to create the characteristics of the district and county public brand, the establishment of direct supply system of agricultural products, focusing on the "last link" of agricultural products sales, the realization of traceability tracking of agricultural products, to strengthen the supervision of the quality of the agricultural products, agricultural products can be increased after-sales service, for example: After-sales service of agricultural products can be increased, such as the function of "bad fruit compensation", and collect consumer and customer evaluation of agricultural products, adjust the planting plan of agricultural products in time, improve the processing of agricultural products, and predict the market demand of agricultural products.

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Note

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