

Green Development of Agricultural Whole Industry Chain: Pathway and Countermeasures

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Abstract: Green development of the agricultural whole industry chain (AWIC) is vital for enhancing the competitiveness of agricultural products and increasing the value-addition of the industry, in addition to improving resource utilization efficiency and to ensure sustainable economic growth. In this study, we have defined the concept of the AWIC green development and analyzed its characteristics based on the existing theories of the AWIC and agricultural green development. Additionally, we analyzed the AWIC development status, the major challenges involved, and the feasible pathways in China. Our study revealed the critical dilemmas of the AWIC green transformation, such as insufficient systematic design, short industrial chain, difficulty in participation of small- and medium-sized entities, low resource utilization efficiency, lack of value-addition, and lack of ecological synergy. The AWIC green transformation and policy support are essential to elevate the values of the whole industry chain. The major pathways for the AWIC green development include internal circulation integration, horizontal expansion, vertical-element integration, and cross-industrial integration. We suggest that China should strengthen top-level design, boost innovation, expand ecological advantages, improve supervision services of the whole industry, as well as explore benefit-coupling mechanisms. These measures can complete the industrial layout, optimize the product value transformation system, and promote the AWIC green development.

Keywords: agricultural whole industry chain; green development; industrial integration; environment friendly; value enhancement

1 Introduction

The integration of the agricultural whole industry chain (AWIC), guided by green development, is the key to safeguarding the rising quality, efficiency, environmental friendliness, and green production transformation of the agricultural sector. China places a premium on the AWIC integration in tandem with the environment. From 2012 to 2019, the national agricultural green development (AGD) index increased from 73.46 to 77.14 (on average, 83.03 in the pioneer zones), and AGD gradually formed a pattern [1] that is better adapted to consumer demand for small-size, high-quality, and refined products [2]. However, issues such as shoddy domestic agricultural production practices, quantity over quality products, lack of celebrity branding, and structural deficit in safe and high-quality products remain unsolved. Furthermore, global carbon taxes and low-carbon barriers will significantly influenced international agricultural product circulation, exacerbating the “bad money drives out good” situation and supply-

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side imbalance in the domestic agricultural market [3]. Therefore, development of the AWIC construction and green transformation is needed for agricultural green and high-quality development to ensure adequate supply of high-quality agricultural goods while improving the quality of ecological environment in China.

Several studies on the AWIC have focused on connotation definition, model categorization, path exploration, and effectiveness analysis, indicating a development trend of constant integration and continuous optimization [4]. Agricultural production and technology development were the initial areas of focus of agricultural industrial chain research; subsequently, the research extended to the market end in “unified purchase and selling” with the development of market economy. Industrialization and urbanization have facilitated rapid integration of research, production, processing, and marketing in the agricultural industry chain, which in turn allows the industry to specialize in scale production. Fertilization formula and green production technologies are the priority areas of AGD. The advent of new development concepts, alteration of consumption habits, and widespread use of information technology have all worked together in recent years to promote green development in the agricultural industry chain [4]. Leading-enterprise-driven, intermediary-organization-driven, professional-market-driven, and other agricultural industry chain operation modes are classified based on the participating entities [5]. Chain type, chain-group type, and chain-net type are the three types of operation modes differentiated by economic factors along the chain [6,7]. Challenges such as industrial barriers, obstructed information, unstable connections, and quality control difficulties can be overcome by modifying value chain composition and optimizing the innovation system. Consequently, food security can be enhanced, output value and circulation efficiency of agricultural products improved, income of farmers increased, and poverty alleviation and agricultural industry growth promoted [8–10].

Previous research on AGD have concentrated on defining connotations, development transformation, assessment index, and realization path [11]. The primary connotation of AGD post its evolution through the various stages, such as germination, development, enhancement, and promotion, is resource conservation, environmental friendliness, clean environment, product quality improvement, and ecosystem stability [12]. Partial and total factor productivity can be measured using data envelopment analysis, stochastic frontier analysis, and other approaches [13]. The entropy method, analytic hierarchy process, and other methods can produce resource consumption intensity/efficiency indicators, environmental friendliness, and habitat environment to develop a complete index system to improve the comprehensiveness of AGD level assessment [14,15]. The paths of improving ecological agriculture's industrial architecture, boosting innovation-driven capability, and constructing a multidimensional guarantee system can all promote agricultural modernization and facilitate AGD transformation and upgrade [16–18]. Agricultural green development has started manifesting in some Chinese regions [19].

The AWIC is a critical component of green transition of agriculture, and the two are interdependent and mutually beneficial. There are relatively few studies that support the development and integration of the AWIC and examine regional AGD from the perspective of green transition of the whole industrial chain, and there are gaps at both theoretical and practical levels. At the theoretical level, the internal logical relationship between the AWIC and AGD is unclear, and the connotation characteristics of the green development of the AWIC and its logical framework remain unclear. At the practical level, the path and mode of the green transformation of the AWIC remain vague, and the path of AGD realization from the perspective of the whole industry chain is yet to be studied [20]. Hence, our study begins with the integration and green transformation of the AWIC, analyzes the current state and challenges of development in this field in China by the way of the connotation and characteristics of green development of the AWIC, proposes a logical framework and key points, summarizes the development path model, and elaborates typical cases, to contribute to the theoretical research on green development of the AWIC in China.

2 AWIC implications and characteristics

2.1 AWIC green development fundamentals

The green development strategy of the AWIC is to prioritize the integration of the whole industrial chain, adhere to the principle of ecological priority and environmental friendliness, carry out industrial upgrading, linkage, and integration, develop agricultural industries and industrial clusters with apparent advantages and distinctive features, and realize synergistic efficiency improvement.

The fundamental requirement of the AWIC green development was to achieve green ecological environment through material flow regulation. The interaction of matter and energy occurs between the AWIC and the ecological environment system. The AWIC requires coordination of the chain management, regulation and optimization of material and energy flows, green transformation of the whole chain with the primary characteristics of recycling,

high efficiency, and full utilization, increased resource utilization efficiency, and meet the needs of green ecological environment (Fig. 1). The corresponding management entails source reduction, process control, and end-of-pipe treatment, strengthening input control of the AWIC from the source to minimize excessive input of resources and pollutants, optimizing the AWIC process management to increase resource utilization efficiency and reduce environmental emissions, and strengthening waste resource reprocessing and reuse to minimize waste generation and reduce environmental pressure.

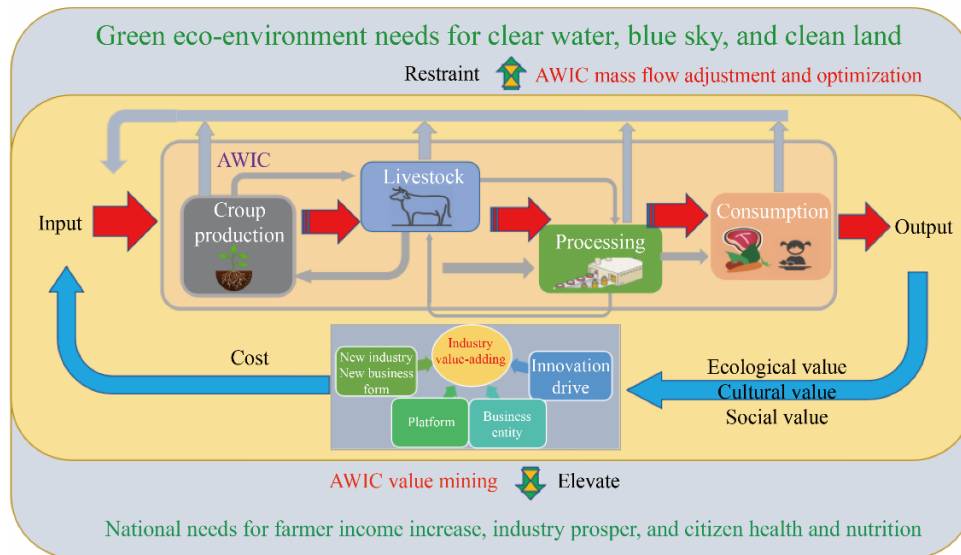


Fig. 1. The logical idea of the agricultural whole industry chain.

The primary objective of the AWIC green development is to determine the value of AWIC integration to increase farmers' income and ensure industrial success, as well as national nutrition and health. The AWIC connects agriculture to tables, acts as a mediator between producers and consumers, and serves as a comprehensive carrier of many links, including production, processing, circulation, and consumption. Value mining, benefit distribution optimization, and value enhancement across the whole industry chain have become direct requirements for AWIC green development (Fig. 1). Agricultural industry and goods have numerous dimensions of value, including ecological, cultural, and social values, and the areas of emphasis are: (1) strengthening technical support to improve the quality of agricultural products, increasing market competitiveness through standardized production and high-quality agricultural products, increasing the price of agricultural products through a high-quality high-price system, and improve the quality and income of the AWIC, (2) strengthening the integration of the three industries by utilizing and maximizing deep processing of agricultural products to tap into new markets, developing agricultural tourism, recreation, education, and other industries through extensive use of ecological and cultural resource endowments, coordinating the multifunctionality of agriculture, and maximizing the income-generating potential of agricultural chain integration, and (3) adhering to systematic thinking, allocating and optimizing resources, and decreasing resource input and loss across the whole chain through industrial integration to achieve cost savings and revenue growth.

In essence, the green development strategies of the AWIC comprise integration of green development throughout the agricultural industry processes, innovation of institutional mechanisms and business models, guiding of resource element convergence, and capitalization on multifunctional values of agriculture. Innovation-led and market-driven integration is the primary driving force behind the integration of AWIC by utilization of scientific and technological advancements to extend industrial chain, enhance value chain, activate factor chain, and improve supply chain; consequently, new kinetic energy can be cultivated for chain integration, technical service and support systems can be improved, and high product quality, industrial efficiency, and supply chain reliability can be achieved.

2.2 AWIC green development properties

AWIC spans the whole food system from farm to table in terms of system boundaries, and it is a multi-goal synergy of green, quality, recycling, and efficiency.

2.2.1 Environmental friendliness

The AWIC shares an interdependent relationship with and influences “mountain, water, forest, field, lake, grass, and sand” community of life. The goal of the AWIC is sustainable development by systemic and bottom-line thinking, which requires the AWIC green development to: (1) integrate system thinking, scientific design, and construction of the AWIC structure, (2) exhibit strict adherence to the baseline of ecological function protection, bottom line of environmental quality and safety, and target of natural resource utilization, and (3) strictly control the ecological threshold by adhering to the bottom line thinking of ecological protection. The AWIC development should not be at the expense of the ecological environment but must develop and be executed within a suitable spatial scope, with a developmental path that also meets the requirements of the ecological environment.

2.2.2 Exceptional quality and safety

Quality and safety are key to the green development strategy of the AWIC. Quality agricultural products are the critical link between production and consumption; in addition, they are the backbone of agricultural product quality and price systems as they are the export component of the AWIC integration. One of the objectives of integrated agriculture is to guarantee the supply of high-quality agricultural goods, fulfil market demand, and integrate production and consumer groups. Quality control and improvement should encompass environmental control at the point of origin, input control, production and harvest management, storage and processing supervision, and market sales licenses to ensure the quality and safety of agricultural products throughout their supply chain.

2.2.3 Revenue growth through value addition

The green development of the AWIC is primarily driven by value-added income generation. The AWIC can meet consumer demand more efficiently—for safe, high-quality, and diverse agricultural products—by integrating production and consumption, as well as raise quality revenue for the industry through a system of high-quality and outstanding prices. Extending the AWIC, increasing the share of processed products, and producing high value-added products can increase the revenue and value of the industry chain. Additionally, integration of the whole industry chain eliminates losses and wastes caused by mismatches in upstream and downstream demand and poor connections, thus lowering production costs. The high efficiency of the internal cycle of the whole industry chain substitutes for some inputs through resourceful use of waste, achieving cost reduction and income growth simultaneously.

3 AWIC status and challenges

3.1 AWIC lacks system design for environmental and regional synergistic development and has insufficient industrial ties

A well-designed system and top-level scientific planning are critical pre-conditions for developing the AWIC. From a system perspective, the AWIC integration should prioritize eco-friendliness, structure industries, and industrial clusters within the bounds of ecological and environmental capabilities, and rationally manage the whole supply chain. However, the introduction of regional agricultural industries and layout of the entire industrial chain continue to prioritize the development of core industries and revenue generation, while they lack a system design that focuses on ecological capacity, thus posing threats to the regional ecological environment and escalating conflicts between industrial and ecological environment. Using the breeding industry chain as an example, research findings [21] showed that the proportion of small-scale, medium-scale, and large-scale breeding with insufficient supporting arable land accounts for 87.18%, 82.35%, 93.33%, respectively, among the eight major pig-producing provinces. According to estimates on total livestock manure, nitrogen and phosphorus loads of livestock manure on arable land, and environmental capacity of livestock farming on arable land, ~ 10%, 59%, and 31% of cities in the middle and lower reaches of the Yangtze River have low, medium, and high environmental risk associated with livestock farming, respectively, indicating that the regional environmental capacity is associated with livestock farming [22].

Due to lack of top-level planning in the construction and integration of the AWIC, the development of regional pillar industries has been hampered by a lack of infrastructure, technical support, supporting industries, and mechanisms to ensure healthy development, as a result, hindering the AWIC development. For example, according to data from the China Federation of Logistics and Purchasing, compared to an average price of 10–15% in developed countries, logistics costs account for ~ 30%–40% of product costs in China, and distribution costs of fresh agricultural products such as vegetables account for 50–60% or more of the selling price [23]. As the absence of a

single link and insufficient support can significantly impede the growth of the whole industrial chain, rational and methodical regional planning must reinforce the whole-chain viewpoint and layout of the AWIC.

The AWIC development lacks a mechanism for regional synergy. For example, the middle and upper reaches of the Yangtze River basin are significant agricultural production and output areas, represented by the Sichuan and Hubei provinces. The Yangtze River Delta region, led by Shanghai, is located in the lower reaches and is a significant agricultural product consumption area with a high demand for high-quality agricultural products and apparent advantages in scientific and technological innovation. However, scientific and technological support is lacking. The share of agricultural products is low, market supply and demand are misaligned, and the problem of agricultural non-point source pollution is severe, all of which fall short of the requirements for high-quality development in the Yangtze River Economic Belt. Compared to the relatively developed Yangtze River basin, agricultural areas dominated by traditional food crops is poorly synergistically developed, where the lack of regional synergy is apparent.

3.2 AWIC short supply chain, confusing manner of benefit sharing, and inconspicuous effects of industry integration and value-addition

In China, the AWIC is short, with low value-addition. Compared with that of industrialized countries, the agricultural processing capacity of China is relatively limited. The processing firms are small and can only process agricultural goods at a slow rate. According to the statistics of the Chinese Academy of Agricultural Sciences [24], the agricultural product processing industry in China generated 23.2 trillion CNY in 2020, with a ratio of nearly 2.4 to 1 agricultural output value. In contrast, the ratio in developed countries exceeds 3:1. Agricultural product processing in China has a conversion rate of 67.5%, which is lower than that achieved in developed countries (~80%).

The AWIC involves various subjects of interest, and its imprecise mechanism of interest distribution hampers its design and evolution. For example, the whole industry chain of dairy products comprises raw milk production, dairy processing, dairy marketing, and other critical links that are “strong in the middle and weak at both ends.” The upstream farming industry is typically less efficient, while midstream dairy enterprises perform well. Owing to the inadequacy of the benefit distribution mechanism, the stark contrast between dairy farmers and dairy enterprises has increased pressure on the quality control of the whole supply chain, as evidenced by the frequent occurrence of melamine and other agricultural safety incidents, which severely impede healthy development of the dairy market in China. Owing to the inertia of customer trust, the relatively tight quality control of some foreign dairy products has resulted in a rapid increase in imports and narrowed the expansion space of local agricultural business. Between 2012 and 2018, the importation of infant milk formula increased by 2.54 times; however, domestic production expanded by only 33.6% and the market share of local brands fell to 43% [25].

The benefits of agricultural multifunctionality have not been thoroughly explored in China, and the degree of integration between agriculture and other sectors, such as tourism, recreation, and cultural heritage, is low. The primary objective of agricultural multifunctionality is to vigorously develop new agricultural production and management forms—such as leisure agriculture and ecological agriculture—and according to the Ministry of Agriculture and Rural Affairs statistics from 2019 [26], national leisure agriculture received 3.2 billion visitors. It generated ~850 billion CNY in revenue, accounting for only 6.9% of the total output value of agriculture, forestry, and fisheries, indicating that the integration of primary and secondary sectors in China lags far behind that of industrialized countries. Promoting agricultural branding is an effective way to increase the income of farmers; however, agricultural brands in China are small and disorganized, lacking national and industry development planning, thus warranting improvement of administrative management standardization. There is a phenomenon of “emphasizing certification over cultivation” in the development of agricultural brands, and market recognition is low due to poor management of agricultural quality.

3.3 Asymmetry information along the AWIC and difficulties in integrating small- and medium-sized entities

The subjects of interest of the AWIC are classified as production, technical service, market consumption, and supervision and service subjects; however, they are affected by widespread information asymmetry, thus impeding the AWIC integration. The information asymmetry between producers and technical service providers causes mismatch between demand and supply for green and high-quality production technology, low rate of agricultural production technology adoption, and constraint on high-quality and efficient production. Additionally, it creates an

imbalance between supply and demand of agricultural products and the market. The price disparity between agricultural products and the frequent occurrence of stagnant and wasteful agricultural products has resulted in a significant loss of enthusiasm among production subjects. However, current AWIC cannot differentiate consumer consumption from demands. The information asymmetry between various subjects and the absence of a quality-oriented production–traceability–supervision system for agricultural products makes it challenging to identify high-quality agricultural products or establish a high-quality price system, thus constraining the value-addition of the AWIC. The primary reason for knowledge asymmetry is that the circulatory body does not supervise agricultural products. The time and space mismatch between agricultural production and consumption of agricultural products and the disparity in the methods used to obtain information results in limited information feedback, which typically requires the participation of a third-party distribution service system; however, such systems are not fully developed, and their credibility needs improvement.

Many Chinese leading agricultural enterprises, such as COFCO Corporation and Fujian Sunner Group prefer to strategically structure their industrial chains through mergers and acquisitions, re-organization, and endogenization to boost their competitiveness and mitigate market competition operation risks. However, in the long run, the fundamental condition of small- and medium-sized farmers as primary commercial organizations remain stable. Small- and medium-sized businesses confront numerous agricultural product varieties, varying quality, and difficulties in standardizing production. They mainly sell primary agricultural products directly and generally do not participate in deep processing and distribution; as a result, processing and distribution enterprises—that buy all commodities simultaneously—do not benefit from back-end profits. It is difficult to establish an effective industrial scale, demonstrating that small- and medium-sized businesses in China’s agricultural output do not play a significant role in the integration of industrial chains. Additionally, due to the low degree of organization of linked production and operation activities, as well as a lack of money, technology, skill, and cognition for industrial operation, small- and medium-sized business topics are excluded from the AWIC.

3.4 Low resources efficiency along the AWIC and challenging production-environmental synergy development

The absence of upstream and downstream matching and the low degree of the AWIC industrial integration in China have resulted in low resource-use efficiency in the industry chain. The fragmentation of arable land and scale of agriculture combine to create a mismatch between farming and breeding, resulting in increasingly visible issues, such as excessive environmental emissions and ecological footprints of agricultural production. The average plot size of China’s three major grain crop production areas is only 1.8–2.85 *mu* (1 *mu* = 666.7 m²), and the scale of livestock breeding is increasing (41% for pigs, 52% for dairy cows, 69% for chicken, and 63% for egg-laying hens). However, the proportion of breeding and planting is less than 50%, and the nutrient utilization rate of livestock and poultry manure is less than 60% (nitrogen, phosphorus, and potassium are 32.9%, 50%, and 53.7%, respectively). Additionally, increase in labor costs results in a decrease in the utilization rate of organic fertilizers (on food crops), coexistence of increased strain on livestock and poultry manure consumption, and insufficient carbon input to arable land [27].

The low degree of integration and poor connectivity of the AWIC, high rate of agricultural product loss, and insufficient resource recycling have resulted in low energy efficiency throughout the chain’s logistics. Moreover, the high environmental costs of agricultural products have exacerbated the problem of agricultural non-point source pollution. For example, in 2014, the food system in China used 8.84×10^7 t of nitrogen, while inhabitants consumed only 6.1×10^6 t. The nitrogen utilization efficiency of agricultural food system was only 7%, while 64% of the nitrogen was released into the environment [28]. According to the *Bulletin of the Second National Pollution Source Census* (2020), the agricultural sources of chemical oxygen demand emissions are primarily livestock and poultry farming (93.8%). In contrast, agricultural sources of total nitrogen and phosphorus emissions are primarily farming (59.1% and 38.2%, respectively). Currently, the quality of surface water in most provinces in China exceeds the critical standard (1 mg-N/L), and nitrogen emissions from water bodies (1.45×10^5 t/a) are 2.7 times that the safe level [29]. Seventy-seven percent of lakes are eutrophic, covering an area that is nearly 60 times larger than it was in the 1980s, and atmospheric reactive nitrogen (e.g., ammonia and nitrogen oxides) emissions have increased 2–3 folds since then, whereas atmospheric nitrogen deposition has increased by more than 60% [30]. Agricultural non-point source pollution has become a significant issue in the management of the ecological environment in China. There is an urgent need for green transformation of agriculture to integrate production and ecology, as well as establish a community of life in mountains, water, forests, lakes, grass, and sand.

4 AWIC green development pathway

4.1 Logic and key points behind the AWIC green development

Increasing the value of each link in the existing industry chain, seeking breakthroughs in institutional processes, and creating the expansion and integration mode of AWIC chain are included under the new development pattern. According to status and national demand, AWIC green development in China requires significant breakthroughs in the following four areas to increase the value of the existing industry chain (Fig. 2).

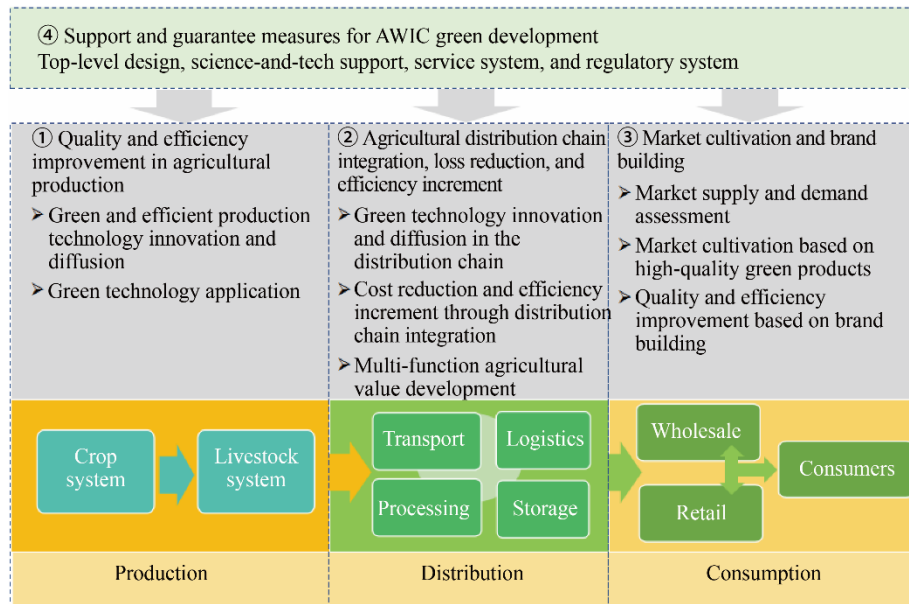


Fig. 2. The logical framework of the agricultural whole industry chain.

4.1.1 Green production enhances quality and efficiency

Quality and efficiency are inextricably linked. Agricultural production is the starting point of AWIC and is also the primary source of environmental emissions. Thus, achieving reduction in green emissions in agricultural production processes, while maintaining an efficient supply of high-quality agricultural products, is critical for improving quality and efficiency. The discovery and dissemination of green and efficient production technologies and their adoption and implementation by production subjects are critical.

4.1.2 Chain integration to minimize losses and maximize efficiency

The distribution chain, which includes processing, storage, and transportation, is the link between the efficiency of production chain and quality and safety of marketed agricultural products. The key elements are green technology innovation and proliferation throughout the distribution chain; integration of processing and distribution to reduce costs and increase efficiency; agro-ecology, culture, recreation, and other multifunctional value development; and matching optimization between distribution chains to achieve loss reduction and efficiency.

4.1.3 Brand development and precision promotion

The aim of targeted promotion is to direct consumption toward green and high-quality agricultural products, cultivate first-class brands, increase the premium price of agricultural products, and establish a high-quality and high-priced marketing system. It also aims to attract green production in response to market demand, increase competitiveness of agricultural products in domestic and international markets, and accelerate AWIC integration and green development. The critical components are dynamic market supply and demand analysis, forecasting of market demand for green and high-quality products, brand certification and cultivation, and integration of organic production and consumption.

4.1.4 Policy improvement to strengthen support

Considering the significant positive externalities associated with green agricultural production as well as the low display of product values, timely research and implementation of ideal policies are necessary to guarantee green agricultural production and high product quality and price. Effectiveness of AWIC green development will be

determined by top-level scientific design, solid technical support, excellent financial services, and a strict supervision system. These factors will improve the quality and efficiency of production and circulation, ensure balance in supply and demand for green and high-quality agricultural products, and promote synergistic development with the environment. They will also contribute to the market system and promote the establishment of high-quality agricultural products.

4.2 Primary approaches of AWIC toward green development

Our case study demonstrates that the four primary paths (industrial integration modes) of green development for AWIC in China are internal circulation integration, horizontal extension and expansion, vertical element integration, and industrial leap integration (Fig. 3).

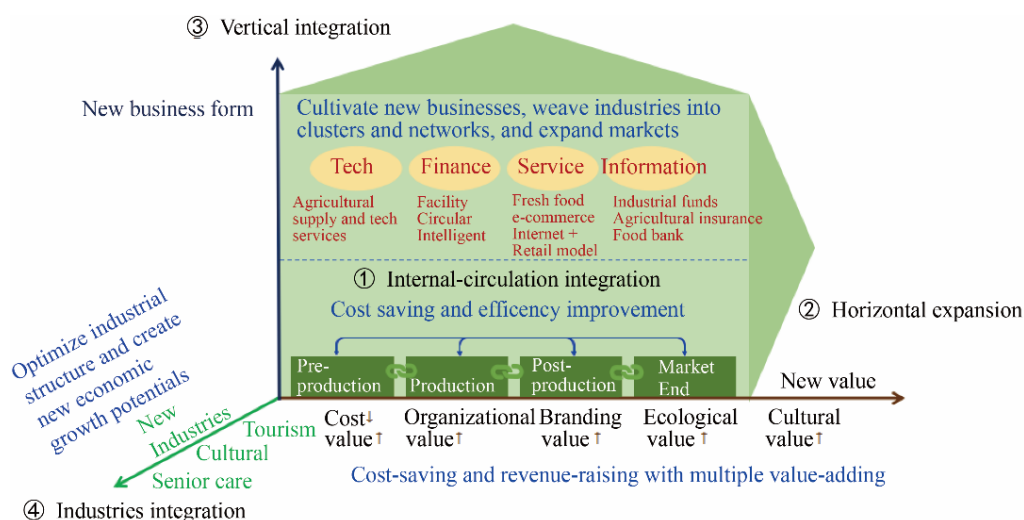


Fig. 3. Primary approaches of the AWIC toward green development.

4.2.1 Internal circulation integration

Internal circular integration entails converting the straight-chain structure of AWIC into a circular one; strengthening the coupling of upstream, middle, and downstream; promoting internal circulation; implementing material recycling principle and multilevel material utilization technology throughout the chain to reduce the amount of waste generated in the AWIC; and promoting creative waste recycling system to achieve loss reduction, cost reduction, and efficacy. Guangze County in Nanping City of Fujian Province is a large broiler breeding county with a slaughter volume of almost 300 million white broilers per year and a manure production volume of approximately 5×10^5 t/a, which is significantly beyond the carrying capacity of local agriculture. Hence, Guangze County organizes enterprises to use chicken manure to produce organic fertilizer (for planting in local and neighboring counties and cities) and establishes a recycling model for the breeding industry (consuming 2×10^5 t/a of chicken manure and generating approximately 400 million CNY in output value); exploring power generation using chicken manure (consuming 3×10^5 t/a of chicken manure) and generating 170 million kWh of electricity (for broiler farms), thereby saving costs of approximately 110 million CNY.

4.2.2 Horizontal expansion

Horizontal extension refers to the process of expanding AWIC from primary industries, such as raw materials and fresh food, to processing/functional industries, such as food processing, biological materials, and clean energy, to improve the quality and value of agricultural products. For instance, grapefruit is a cornerstone agricultural commodity in Changshan County in Quzhou City of Zhejiang Province, but competition from domestic citrus products has resulted in its low sales in recent years, limiting the development of allied companies and income of farmers. In response, Changshan County organized enterprises to develop grapefruit processing, perfected the AWIC path through grapefruit deep processing and medicinal herb utilization, and developed nearly 20 types of agricultural by-products such as grapefruit tea, grapefruit essential oil, grapefruit mask, and Qhu Hovenia shell. Twelve deep processing enterprises were established within the county, and the volume of grapefruit deep processing exceeded 3.8×10^4 t/a, with an output value of approximately 400 million CNY. The traditional grapefruit industrial chain has been modernized into a provincial-level AWIC model with a one-billion-CNY scale.

4.2.3 Vertical integration

Vertical integration refers to the rapid development and widespread application of information technology, such as the Internet, big data, cloud computing, and other information technologies, to promote the active integration of science and technology, data, capital, and other factors of AWIC, thereby enhancing the quality and efficiency of the industry through science and technology, expanding the market and increasing income through information, and achieving a significant improvement in them. For instance, the smart agricultural greenhouse in Dongpo District of Meizhou City in Sichuan Province covers 112.8 *mu* and is mainly used to grow tomatoes, cucumbers, peppers, and other vegetable species. The annual output of vegetables in greenhouses is four to five times that of traditional greenhouses, water consumption is reduced by more than 90%, the unit price of sales is increased by over 15%, total revenue is increased by six to seven times, and the annual output value exceeds 80 million CNY.

4.2.4 Industries integration

Industrial integration entails exploring the functional aspects of labor and employment security, ecological nurturing, inheritance of farming culture, cultural tourism and recreation, and folklore experience, among others to promote the integration of agriculture with tourism, culture, education, and other tertiary industries and stimulate the endogenous power of agricultural production. For example, Quzhou City in Zhejiang Province leverages agricultural production and ecological resources to create Beautiful Orchards, Beautiful Teagardens, Beautiful Rice Fields, Beautiful Flower Fields, and Beautiful Countryside to integrate tourism, cultural tourism, recreation, and other service industries, and cultivate the agricultural ecological economy industry. Tourism agriculture (agritainment) hosted 54.12 million visitors, and the production value of leisure tourism agriculture reached 3.08 billion CNY, accounting for 34.8% of the overall agricultural, forestry, animal husbandry, and fishing output values.

5 Countermeasure

5.1 Strengthening the top-level design of AWIC system and optimizing its layout

AGD is a systematic project that requires a balance between green and development as well as coordination of environmental carrying capacity with economic growth, agricultural product supply, and ecological services. At the regional level, it is important to begin with ecological protection, calculate resource and environmental carrying capacities based on regional positioning and endowment, maintain the integrity of the “landscape, water, forest, cropland, lake, and grass” system, and ensure territorial spatial planning coordination to reasonably layout the AWIC. At the industrial planning level, it is important to strengthen the coordination of AWIC development based on regional advantages by prioritizing the construction of markets and distribution areas; and planning agricultural production, processing, circulation, and consumption industries rationally. Market mechanisms and subjects should play a critical role in integrating information, science and technology, talent, and other factors. An agriculture development pattern that is compatible with the carrying capacity of environment and resources and coordinates with production, life, and ecology should be formed.

5.2 Implementation of the innovation-driven and green development strategies of AWIC

Based on scientific and technological innovation, AWIC green development needs to optimize factor allocation to stimulate industry upgrading, establish new economic growth, promote the deep integration of science, technology, and information, create new industrial forms, develop new market spaces, increase market demand, and transform industrial clusters into chains and networks. In addition, AWIC green development should be able to amplify the effect of industrial clusters, encourage industrial crossover, devise an industrial development strategy via innovation and integration and spiral upgrading, and improve production quality and efficiency. For talent cultivation, it is necessary to modernize the mechanism in response to industry demands, develop inventive, managerial, and comprehensive talent groups, and lay the intellectual groundwork for industrial upgrading, scientific control, and systematic AWIC upgrading. For mechanism innovation, we should adjust the scientific and technological research project organization and implementation mode and encourage enterprises to act as the primary body for the implementation of scientific and technological innovation; promote the precise alignment of scientific and technological innovation and industrial demand; provide rewards for the transformation and application of agricultural scientific and technological achievements; and accelerate the development of new economic systems.

5.3 Improving ecological benefits and efficient transformation of the value of ecological products

Green development is considered as the fundamental concept for developing AWIC and focusing on sustainable development. Conservation of resources, recycling, and promoting green development helps achieve energy conservation, loss reduction, consumption reduction, and emission reduction throughout the agricultural chain; establish a resource–processing–product–resource cycle; and develop a safe, high-quality, green, and healthy food industry. Based on a sustainable balance between production, life, and ecology, we need to develop a branding strategy for green agricultural products, establish a complete value-addition chain for green agricultural products, and exploit the multifunctionality of agriculture. Further, we should investigate the ecological, cultural, and social values of the industry, promote industry integration, increase agricultural value-addition, and expand the market. At the regional level, it is necessary to achieve industry greening considering agriculture as a foundation, promote green industrialization by focusing on ecological resources, and develop a new industrial development pattern through a production–ecological dual-cycle, thereby forming the green development model for AWIC integration.

5.4 Improving monitoring and services and establishing a model with high-quality agricultural products at reasonable rates

The quality and price of agricultural products are critical factors in agricultural revenue growth. It is essential to develop quality grading standards for agricultural products that incorporate safety, nutrition, health, quality, and environmental characteristics, cover the entire chain of certification and supervision from the beginning to market access to the high-quality agricultural products, facilitate the standardization of the relationship between production and consumer market (demand and supply), and address consumer demand diversification and differentiation. The following points should be considered in particular: (1) improvement of agricultural quality and efficient service systems, providing technical support for green production systems, enhancing safety and quality grading standards for agricultural products, and increasing the supply of green and high-quality agricultural products from the source region; (2) strengthening the quality-oriented market access system for agricultural products and establishing an information-connection mechanism between production and consumption; (3) strengthening the supply of green and quality agricultural products from the source region.

5.5 Investigation of interest-linked mechanisms for ensuring and increasing the income of farmers

Agricultural production is the foundation of AWIC, and AWIC green development should prioritize improving the income and welfare of farmers. Development should focus on agricultural and rural production subjects, with counties, townships, and villages serving as the fundamental units to safeguard the primary positions of farmers and develop processing, tourism, and services in production place. In addition, it is important to increase agricultural efficiency through secondary and tertiary industry development, improve the income of farmers, and promote urban–rural integration and rural revitalization. Furthermore, we should actively cultivate leading enterprises, encourage them to take on social responsibility, and create a balance between enterprise and agricultural interests. In addition, it is essential to develop farmer-sharing industries, investigate new benefit-sharing and win-win models such as contract farming or company + base + farmer, stimulate the growth of small- and medium-sized business entities, and provide a solid guarantee for rural revitalization and shared prosperity.

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