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Developing from Mechanized to Smart Agricultural Production in China

Luo Xiwen[1, 2], Liao Juan[1, 2], Zang Ying[1, 2], Ou Yinggang[1, 2], Wang Pei[1, 2]

1. College of Engineering, South China Agricultural University, Guangzhou 510642, China
2. Key Laboratory of Key Technology on Agricultural Machinery and Equipment (South China Agricultural University), Ministry of Education, Guangzhou 510642, China

Abstract: Transforming the method of agricultural production is a common concern worldwide. Currently, mechanization is being significantly promoted in the agriculture sector in China, and smart production is an inevitable trend for modern agriculture. Data, knowledge, and intelligent equipment are the core elements of smart agriculture, which integrates modern science and technology with agriculture to realize digital perception, intelligent decision-making, precise operation, and smart management throughout the entire process of agricultural production. This significantly improves labor productivity, resource utilization, and land output rate. This article presents the status of agricultural production using rice production as an example, and analyzes the necessity, opportunities, challenges, directions, and routes for the intelligent transformation of China's agriculture. Furthermore, we provide policy suggestions to promote intelligent production development, including (1) strengthening the research and innovation system for agricultural machinery, (2) improving the agricultural machinery promotion system, (3) optimizing the socialized service system for agricultural machinery, and (4) accelerating the construction of smart agriculture demonstration zones.

Keywords: agricultural production; rice production; agricultural mechanization; information technology; intelligent agricultural machinery; smart agricultural production

1 Introduction

Agricultural production is directly related to the survival, development, and social stability of humans. China is a large agricultural country, with agriculture being the basis of its national economy. The development of agricultural production can be broadly divided into four stages. The period of an agricultural society, which is an era of traditional production based on human- and animal-power operations, is known as agriculture 1.0. The period of the industrial society, which is an era of mechanized production based on mechanized operations, is called agriculture 2.0. The period of the information society, which is an era of automated production based on automated operations, is called agriculture 3.0. The period of smart society, which is an era of intelligent production characterized by unmanned operations, is called agriculture 4.0.

Achieving a safe food supply is a top priority for China's agricultural production and development. The demand for rice and wheat is expected to continue to grow until 2050, with the demand for meat, eggs, milk, and other agricultural and livestock products also significantly increasing. Specifically, the demand for fish and dairy products will be more than three times the current demand, and the demand for fruit, livestock products, feed grains, edible oils, and fibers will be 1.5–1.6 times the current demand. The demand for sugar and vegetables will increase by 100% and 75%, respectively [1]. The current growth in the demand for food and changes in the

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Corresponding author: Luo Xiwen**,** professor of College of Engineering of South China Agricultural University, member of Chinese Academy of Engineering. Major research field is agricultural engineering. E-mail: xwluo@scau.edu.cn

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structure of food consumption are placing higher demands on agricultural production. Therefore, to ensure food security in China, it is vital to support scientific and technological progress and accelerate the transformation of agricultural production methods.

Since the reform and opening up, significant progress has been made in developing agricultural production mechanization in China, which contributed to promoting improved labor productivity, land output rates, and resource utilization rates of agricultural production, as well as ensuring food security. At present, with the accelerated development of the technological revolution and industrial change, traditional methods can no longer meet the needs of modern social development. “Who will cultivate and how to cultivate” is a common problem for agriculture in China and the world.

Based on smart agricultural machinery and equipment, with data and knowledge as the core elements, smart production will deeply integrate modern advanced technology with agriculture, significantly improving labor productivity, land output rates, and resource utilization. The advanced agricultural force will promote digital perception, precise operations, intelligent decisions, and intelligent management in the process of agricultural production. It is also an inevitable trend of social development.

Considering rice production as an example (mainly including the five stages of tillage, planting, field management, harvesting, and drying), we introduce the current development of agricultural production in China. This study analyzes the social needs, opportunities, and challenges related to the transformation of China’s agricultural production to an intelligent production mode. A future development direction is proposed, and countermeasures for transforming China’s agricultural production into a smart production method are suggested.

2 Development status of agricultural production in China

With the invention of the steam engine, society entered the industrial era, and agricultural production entered the era of mechanization, with China entering the era slightly later than other countries. With the deepening of reform and opening up, China’s agricultural production has gradually started to utilize mechanization. This paper uses rice production as an example to introduce the development of mechanization.

2.1 Tillage

Currently, tillage machinery such as a moldboard plow, rotary cultivator, subsoiler, and laser land leveling equipment are gradually replacing human- and animal-power plows. Laser land leveling technology has been widely applied and can effectively provide 30–50% water savings while increasing land utilization by 9%. This technology can substantially improve the efficiency of fine land leveling operations while increasing yields by 20–30% and achieving good economic benefits [2]. For example, in paddy field tillage, the height difference in the field surface should be less than 3.3 cm, which is difficult to achieve using human and animal operations. The laser land leveling machine developed by scientific research institutions in China has successfully achieved this requirement [3–5]. In addition, leveling instruments such as a total station, ground laser, scanner, and unmanned aerial vehicle (UAV) laser scanner can be used to quickly collect farmland leveling information. A farmland 3D terrain real-time acquisition system based on the global navigation satellite system (GNSS) has been developed to obtain farmland flatness information quickly and precisely during leveling operations [6].

China does not have significant innovation ability for tillage machinery currently, and more than 80% of the essential technologies come from abroad. The dependence on major equipment from foreign technologies is sometimes greater than 90%. There are many small, single-function, and medium- and low-quality tillage machines, but few large- and medium-sized, multifunctional, and high-quality tillage machines in China. It is necessary to strengthen the independent innovation, optimize and adjust the supporting proportion, and develop tillage technologies for large-scale overall combined structures using hydraulic systems to adjust machine parameters, and changes of operations.

2.2 Planting

Rice planting mechanization is the current bottleneck for the whole industry. Most challenges facing mechanized transplanting technology for conventional rice have been solved, with mechanical direct seeding being a simple and efficient planting method. The direct seeding of rice has the characteristics of a low tillering node, no root injury, and no rejuvenation stage, which saves work input, time, and labor, resulting in high production efficiency. Mechanical direct seeding can lead to a high yield, good quality, and remarkable comprehensive benefits while saving more than 95% of manual and 70% of mechanical labor costs [7]. At present, the “three

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synchronization" rice precision direct seeding technology is widely used. First, water storage ditches are opened on the paddy field while a seeding ditch is opened on the ridge surface of the two water storage ditches. Second, the seed metering device evenly sows rice seeds in the seeding ditch through hill seeding. The row spacing is optional, hill spacing is adjustable, and seeding quantity is controllable. This technology has been popularized and applied in 26 provinces and cities in China and six foreign countries, with remarkable social and economic benefits being achieved. However, the smart mechanization level of the planting stage is low, and the problem of unbalanced and insufficient crop and regional development is still apparent. It is necessary to strengthen the research on the suitability of smart planting machinery for economic crops such as vegetables and those planted on southern hilly areas.

2.3 Field management

Field management mainly includes the management of water, fertilizer, and pesticides. The application of field management machinery and technology such as drip and micro-sprinkler irrigation systems, synchronous seeding and variable rate fertilizer machines, and air spray systems in agricultural production has significantly improved the utilization rates of water, fertilizer, and pesticides, saving resources, and reducing environmental pollution. To provide precision irrigation, sensors are embedded in the soil to accurately determine its water content. Precision irrigation and the integrated irrigation of water, fertilizer, and pesticides are realized based on the water requirements of crops in different growth periods [8,9]. To achieve precision fertilization, the real-time and online proportioning of various fertilizers is realized using a fertilizer applicator with automatic fertilizer mixing [10]. A variable rate fertilization system can meet the actual production requirements and reduce the error of shallow and deep fertilization. Compared with traditional fertilization methods, a variable rate fertilization system can reduce the amount of fertilization by 12% [11]. To achieve precision pesticide application, advanced technologies such as automatic adjustment of the spray pressure and flow are widely used in ground spraying machinery and aviation plant protection machinery [12].

Owing to the various crops and different planting methods in China, it is difficult for existing irrigation systems, and fertilization and pesticide application machinery, to meet the fertilization and pesticide application requirements of different crops in different regions. Efforts are needed to achieve comprehensive (crop and regional) smart irrigation, along with fertilization and pesticide application operations.

2.4 Harvest

Mechanical rice harvesters have replaced manual harvesting. Yield, moisture, flow, loss, and impurity rate sensors have been installed on some harvesters, which improved their intelligence level. A practical large-scale intelligent grain harvester has been developed with automation, intelligent control, and other advanced technologies. It has broken the monopoly of foreign technologies in the market, and can be used for harvesting rice, wheat, soybeans, and other grain crops [13]. A remote precision service system based on the GNSS has realized remote real-time fault diagnosis and maintenance guidance for the harvester.

The current degree of intelligence for rice harvesting machinery in China is not high, and the working effectivity is not ideal. The mechanized harvesting levels for potatoes, tea, peanuts, vegetables, and other crops are still low or non-existent. It is necessary to independently develop harvesting machinery suitable for different crops and regions according to China's crop planting modes to achieve large-scale standardized production and improve the intelligence level of harvesting machinery.

2.5 Rice drying

Rice drying is the last key link in the mechanization of the rice production process, and it is a necessary technical step to ensure the quality of rice storage. Hot air, vacuum, microwave, heat pump, and far infrared drying, as well as different combinations of two drying technologies such as hot air/microwave, microwave/vacuum, and heat pump/far infrared drying are the main technologies concerning to rice drying in China. At present, because of technology, cost, and site limitations, hot air drying is still the most widely used. Rice drying systems can reduce the moisture content of rice from 28.4% to 13.6%. The work efficiency of this system is 14.13 t/h, and the cost is 15.16 CNY/t [14]. The variable temperature hot air drying system changed the traditional constant drying temperature of 47 ℃ to a variable temperature drying process with 5 ℃ and 10 ℃ variable temperature ranges. After drying, the rate of rice kernel cracking decreased by 20% and 10%, the head rice rate increased by 12.6% and 7.7%, and the time required to reach a safe storage moisture content of 14.5% was reduced by 30 min and 60

min, respectively [15].

With the vigorous promotion of agricultural modernization in China, mechanical rice drying technology should achieve lower carbon emissions, improved intelligence and efficiency, and play a greater role in ensuring the storage of grain.

3 Social development demands transformation of agricultural production to smart production mode

3.1 Demand to improve labor productivity

In 1952, China's total population was 575 million, and the population of the agricultural labor force was 173 million; thus, each individual in the agricultural labor force supported 3.32 people. In 2019, China's total population was 1.4 billion, and the population of the agricultural labor force was 194 million, which meant that each individual in the agricultural labor force supported 7.2 people [16]. By 2050, China's total population will be 1.365 billion, but the proportion of the agricultural labor force will be less than 10% [1]. According to statistics, from 2003 to 2019, for every 1% increase in the comprehensive mechanization rate of crops, the urbanization rate increased by 0.53 percent, while the proportion of the agricultural labor force in the total social labor force decreased by 0.64 percent [17]. This showed that agricultural mechanization could significantly improve labor productivity and feed more people with a smaller agricultural labor force. Therefore, by 2050, each individual in the agricultural labor force will need to feed at least 10 people in China. This goal can only be achieved by developing agricultural mechanization and improving labor productivity by realizing smart agriculture.

3.2 Demand to improve land production rate

In 1949, the per unit area yields of rice, wheat, and corn were 1892.29, 642.10, and 961.66 kg/hm^2, respectively. With the adoption of advanced agricultural science and technology such as agricultural mechanization, rice varieties, and planting methods, the per unit area yields of these three crops were increased to 7043.22, 5742.09, and 6317.74 kg/hm^2, respectively, in 2020. These values are 3.7, 8.9, and 6.6 times those of 1949, respectively. At present, China's per capita cultivated land area is only 0.86 hm^2 per person [18]. With the development of industrialization and urbanization, China's agricultural land will become scarcer. Therefore, improving the agricultural land output rate through smart agricultural production is one of the fundamental ways to feed a large population with limited agricultural land.

3.3 Demand to improve resource utilization

According to statistics, from 1991 to 2020, with the adoption of precision irrigation technology, the effective utilization coefficient of irrigation water has increased from 0.358 to 0.56. By adopting precision fertilization technology, fertilizer savings of approximately 15–40% can be achieved [19]. Using precision pesticide application technology, pesticide savings of 40–60% can be achieved [20,21]. In 2020, the utilization rates of fertilizers, pesticides, and farmland irrigation water for rice, corn, and wheat crops were 40.2%, 40.6%, and 55.9%, respectively [22]. The utilization rates of chemical fertilizers, pesticides, and farmland irrigation water in the production of wheat, corn, and other food crops in developed countries such as the United States and those in Europe are 50–65%. Overall, the effective utilization rate of agricultural resources is low in China, and there is still a certain gap compared to developed countries. Therefore, precision agricultural production technology and effective utilization of agricultural resources such as water, fertilizer, and pesticide must be promoted.

3.4 Demand for green agriculture development

Agriculture is one of the major greenhouse gas emission sources in the world. The annual CO_2 emissions from global agriculture are 21–25% of the total [23]. It is predicted that if no emission reduction measures are taken, agricultural CO_2 emissions will increase by another 30% by 2050 [24], which will severely affect the realization of the global carbon emission reduction target. Since 1978, China's agricultural carbon emissions have continued to grow at an average annual rate of 5% [25], and China's agricultural greenhouse gas emissions account for approximately 17% of the country's total greenhouse gas emissions [26]. The development of green agricultural technologies will play an important role in achieving the goal of decreasing carbon dioxide emissions and neutralizing carbon. There are three requirements for agricultural green production: (1) the production process for agricultural machinery and equipment must be green (i.e., there is no or less pollution), (2) the working process for

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agricultural machinery and equipment should be green (i.e., during use, the fuel consumption and tail gas emission should be minimized to reduce the compaction and damage to soil), and (3) agricultural machinery and equipment must realize green operations (i.e., they must achieve precision fertilization, pesticide application, and irrigation to effectively utilize water, fertilizer, pesticide, and other resources, thereby reducing production costs and environmental pollution) [27].

4 Opportunities and challenges for smart development of China's agricultural production

4.1 Opportunities for smart development of China's agricultural production

4.1.1 Rural revitalization

Rural revitalization is a major strategic deployment proposed by the 19th National Congress of the Communist Party of China. China has established an important policy of prioritizing agricultural development. It is an important policy to promote agricultural development and rural modernization and has made historic achievements. China's agricultural and rural modernization has made breakthrough progress. The agricultural infrastructure has been significantly improved, and significant progress has been made in the construction of high-standard farmland with high and stable yields. Decisive achievements have been made toward the goal of alleviating poverty and policy coverage has reached 98%. The growth rate of farmers' per capita income has been higher than that of urban residents for 10 consecutive years. It was predicted that by 2020, the per capita disposable income of farmers in China would reach 17 100 CNY [28]. The rural revitalization policy has improved the construction of agricultural infrastructure and increased farmers' income. This has enabled farmers to purchase agricultural machinery and provided support for the transformation of agricultural production to smart production.

4.1.2 Financial support for agriculture

At present, China's fiscal policy of supporting agriculture is continuously being improved. The agricultural financial support structure has continuously improved, and the support intensity has continuously increased, which will effectively promote the intelligent production of agriculture and lay a robust economic foundation for the transformation of the agricultural production mode. According to statistics, China's total financial support for agriculture increased from 269 million CNY in 1952 to 2390.362 billion CNY in 2020 [29,30]

4.1.3 Machinery manufacturing

The development of China's machinery manufacturing field provides a foundation for intelligentizing agricultural machinery and equipment. China has achieved remarkable progress in machinery manufacturing. These are mainly reflected by breakthroughs in numerous key core technologies and products, with a significant enhancement of technology breakthrough and innovation abilities. We have achieved breakthroughs in the bottleneck and shortboard problems in the core links of numerous key areas and have steadily improved our basic research and innovation capabilities. Smart manufacturing has been accelerated, and many new smart manufacturing models and industries have developed. The deep integration of information technology and accelerated development of the manufacturing industry in the direction of networking, digitization, and smart systems led to supporting the development of agricultural machinery and equipment manufacturing in the direction of smart systems.

4.1.4 Information technology

The deep integration of information and agriculture is essential for developing the agricultural production mode from mechanization to smart systems [31]. Agricultural machinery information integration refers to the integration of modern information technologies such as the Internet of Things, fifth-generation mobile communications, sensing technology, cloud computing, and artificial intelligence with agricultural production methods, which will make agricultural machinery safer, more dependable, and more efficient. Compared with traditional agricultural machinery, agricultural machinery informatization can improve the operation efficiency by approximately 50%–60%, while ensuring operation quality [32]. Based on information technology, agricultural machinery and equipment will be equipped with intelligent systems, which will provide precision sowing, fertilization, pesticide application, weeding, and harvesting functions, and the development of smart agriculture.

4.2 Challenges for smart development of China's agricultural production

4.2.1 Backward smart agricultural production infrastructure

At present, the infrastructure for developing smart agricultural production in most parts of China is relatively backward. The construction of a network infrastructure in some rural areas is lagging. The coverage of rural broadband and fiber-optic facilities is far from meeting the requirements of smart agriculture development. The equipment cost is high, while the actual income of Chinese farmers is low. Thus, purchasing the mechanical equipment required for smart agricultural production is difficult, which limits their popularization and application.

4.2.2 Low level of smart agricultural informatization

Information technology is one of the core elements in smart agricultural production mode development. Currently, the informatization levels of many agricultural production areas are low, which is mainly reflected in the following aspects. First, China's smart agricultural information data have low standardization and precision, and insufficient coverage. Second, there is a lack of agricultural information and data sharing systems, and the information and data belonging to different departments cannot be shared. Third, there are few agricultural information platforms in China. The information application websites and data analysis platforms established for agricultural production are small in scale and low in information precision, while the precision and timeliness of the data analysis are low. The above problems lead to low support from China's agricultural information data for smart agricultural production, which makes promoting intelligent agricultural production difficult.

4.2.3 Lack of smart agricultural talents

Smart agriculture integrates scientific production, information, and intelligent machinery equipment technologies. Therefore, smart agricultural production requires many high-quality technicians, operation and maintenance personnel, and system managers with knowledge in both the agricultural and modern information technology fields. The proper use, maintenance, and management of smart agriculture systems can make them more effective. However, the current education level of agricultural employees is generally low, especially in remote rural areas. The overall cultural level of farmers is low, and their acceptance of and ability to apply emerging technologies such as agricultural mechanization and Internet technologies are not great, which is not conducive to the development, popularization, and application of smart agriculture in China.

5 Development direction and route of agricultural production in China

5.1 Development direction of agricultural production in China

Agriculture will develop in the direction of intelligent agricultural production. This will include the application of information technology such as the Internet of Things, satellite positioning, sensing technology, and intelligent control to traditional agricultural machinery based on traditional agricultural production methods, which will achieve digital perception, intelligent decision-making, precision operation, and intelligent management of the agricultural production process.

5.1.1 Digital perception

Agricultural sensing and Internet of Things technologies are the core of digital perception. The focus is on developing high-precision sensors with high reliability, high stability, and low cost, which are suitable for various agricultural production environments, as well as the development of multi-purpose miniaturized sensors capable of sensing various parameters, including micro-electro-mechanical systems (MEMS), microelectronics, biomimetics, biosensors, and others.

The wide use of self-developed agricultural wireless sensor networks to improve the real-time ability and reliability of agricultural data information is one of the development directions of digital perception. It is necessary to accelerate the realization of intelligent sensors, information detection, and data analysis for agricultural machinery and to realize intelligent decision-making and accurate operations under the coordination of soil, crops, machines, and environmental sensors. It is also necessary to develop a new generation of sensors for agricultural machinery using MEMS technology, which can realize the miniaturization of agricultural machinery sensors and improve the detection precision and stability. The development of new bionics and biosensors to apply to different agricultural machinery applications is required. Advancement of sensor application based on machine vision, real-time kinematic global navigation satellite systems, and inertial technology fusion is required to improve the automation level of unmanned operations and smart breeding in animal husbandry and aquatic products, and to

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promote the formation of new planting and breeding modes.

5.1.2 Smart decision-making

Based on the spatiotemporal characteristics of agricultural production, smart agriculture can provide smart decision-making for agricultural production processes. Investing appropriately, at the right time, and in the right place can make rational use of agricultural production means, reduce costs, and obtain the best economic, social, and environmental benefits. For example, smart decision-making would facilitate improvements based on the growth of the rice, the water and nutrients in the soil, and the water and nutrient requirements of rice at different growth stages. Rapid collection technology for agricultural information is becoming increasingly mature with the continuous development of remote sensing technology, geographical information system, global positioning system, and other technologies. The direction of smart decision-making systems should be supported by the development and application of related technologies. Driven by data, a decision-making model that combines knowledge and data is adopted to effectively associate precision agriculture decision-making with smart computing methods. Based on a database, causality, and time series, agricultural production is evaluated and predicted, which can provide smart decision-making for agricultural production.

5.1.3 Precision operation

Focusing on the efficient and intelligent production of grain, horticultural, and cash crops, intelligent operation equipment such as precision tillage, planting, fertilization, pesticide application, irrigation, and harvesting equipment should be developed for plowing, planting, management, and harvesting, based on the efficient production needs of different regions, including those for dry farming in the north, paddy fields in the south, and hilly mountainous areas. This will promote the formation of a precise operating scheme for intelligent agricultural production. Focusing on the development trend of the new generation of artificial intelligence technology and the needs of smart agricultural production, we should carry out research and development on remote augmented reality control operating systems, medium and large agricultural robot autonomous operation systems, and micro and small agricultural robot cluster and collaborative operation systems. Communication and safety control, high-precision target recognition and path planning, human–machine interaction systems, high-speed high-precision drives, and terminal operation mechanism research should also be carried out.

Livestock and poultry breeding environment construction and regulation, individual and group animal identification and perception, and intelligent feeding systems should also be developed. An automatic inspection robot for animal growth and breeding environments, and an efficient fecal sewage treatment system, should be developed.

5.1.4 Smart management

The intelligent management levels of agricultural machines have improved through information technologies, including remote dispatching, equipment monitoring, early fault warning, and remote maintenance guidance. (1) In terms of remote scheduling, GNSS technology is used to obtain the working location and operation trajectory of agricultural machinery remotely in real time. Agricultural machinery scheduling is carried out according to the production needs and the shortest transfer path principle to improve machinery efficiency. (2) In terms of equipment monitoring, the operating parameters of key components are collected in real time using various sensor technologies during agricultural machinery operations and sent to manufacturers and management departments. (3) In terms of early fault warning and remote maintenance guidance, agricultural machinery production enterprises and management departments make judgments on the real-time acquisition of equipment status and operation quality information. In case of machine failure, the driver can immediately be guided remotely for maintenance. For faults that the driver cannot eliminate, the agricultural machinery maintenance personnel closest to the faulty machinery are immediately notified, and the machinery is sent to repair.

5.2 Development route of agricultural production in China

The development route of China’s agricultural production is shown in Fig. 1. The overall objectives include the following. By 2025, the entire process for China’s main crop production will have achieved basic mechanization. By 2035, China’s agricultural production will be fully mechanized and developing toward intelligent systems. By 2050, agricultural production will be intelligent and developing in the direction of smart systems.

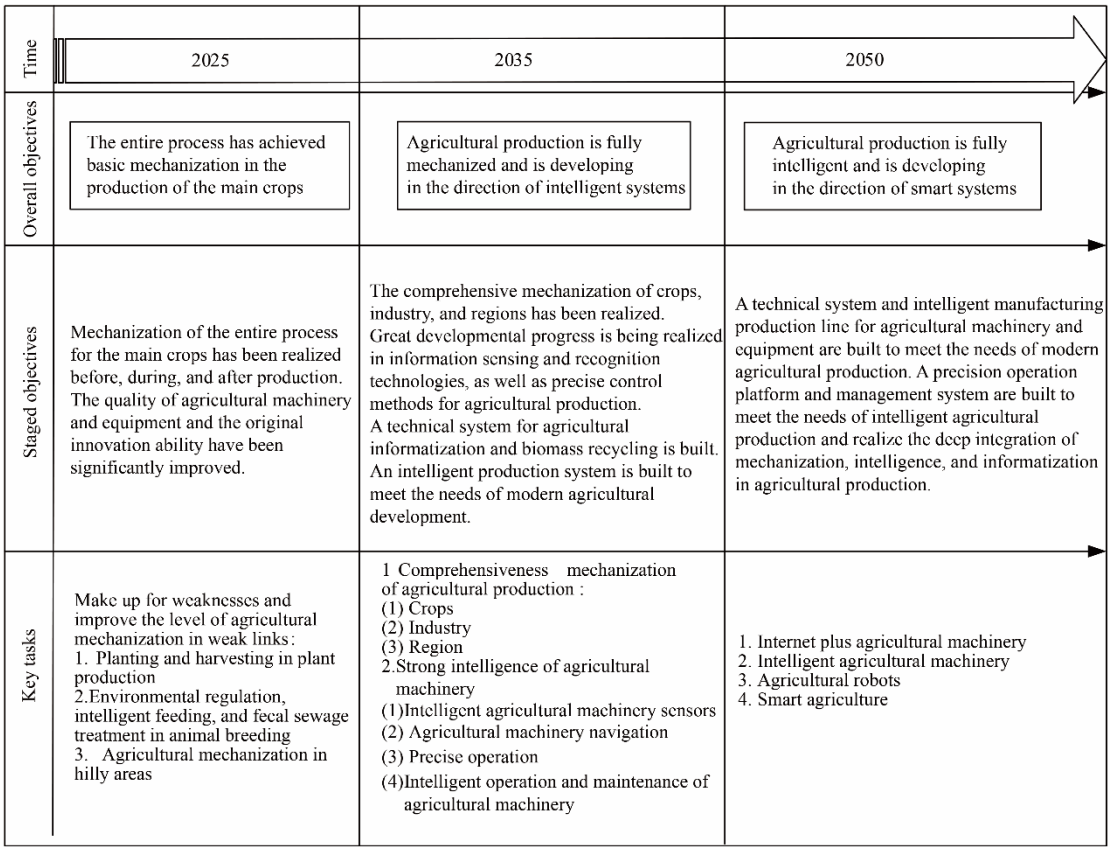

Fig. 1. Development line map of agricultural production in China.

6 Countermeasures and suggestions

6.1 Strengthening construction of research and innovation systems for agricultural equipment

First, to strengthen innovation platform construction for agricultural equipment at all levels, the current innovation platforms should clarify their position, strengthen their responsibilities, and raise their output. Meanwhile, according to the requirements of modern agricultural construction, numerous key laboratories and engineering centers such as “animal–environment–facilities” need to be established. Second, to strengthen research integration and innovation conducted in industry and academia, the state and relevant departments should introduce relevant policies to support agricultural machinery and equipment manufacturers to strengthen scientific and technological innovation. Thus, agricultural equipment manufacturers can gradually become the main target of technology innovation for agricultural equipment in China. Third, to promote innovation in project establishment and the management mechanisms for scientific research projects, changing the previous status of small and scattered scientific research projects conducted in isolation is necessary.

6.2 Strengthening construction of agricultural machinery popularization system

First, to strengthen a popularization team, it is necessary to strengthen the construction of an agricultural machinery popularization system, build township service stations according to local conditions, and establish training mechanisms for agricultural machinery popularization staff. Second, it is necessary to effectively solve the funding problem of agricultural machinery popularization. According to the *Law of the People’s Republic of China on Agricultural Technology Popularization*, people’s governments shall incorporate the funds for agricultural machinery popularization into the financial budget. Subsidies shall be given according to state regulations. The promotion mechanism and funds to encourage agricultural machinery manufacturers to innovate new technologies and new machines shall be established. Third, to strengthen the management and service innovation of the system, provincial agencies shall formulate development plans and annual work priorities, clarify objectives, and implement measures according to the national agricultural machinery development plan and requirements in all provinces.

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6.3 Strengthening construction of socialized service system of agricultural machinery

First, to strengthen the guiding role of government, the agricultural departments of all provinces, municipalities, and counties shall formulate the construction plans and relevant policies of the socialized service system of agricultural machinery in their respective regions according to the local resource endowment. Second, to strengthen policy support, it is necessary to give more subsidies and loans for the purchase of agricultural machinery to agricultural machinery socialization service organizations. Land and loan support shall be given for constructing infrastructure such as hangars. Support shall be provided for constructing socialization services such as start-up funds, post subsidies, and insurance. Third, it is necessary to guide and promote the management and service innovation of agricultural machinery socialization service organizations. Furthermore, it is also important to plan and build a regional agricultural production service platform, establish rules and regulations, strengthen the cooperation between agricultural machinery socialization service organizations and various new business entities, innovate service models, and strengthen the construction of an information platform.

6.4 Accelerating construction of smart agriculture demonstration area

First, to establish a multiple subject co-construction model, it is necessary to speed up the establishment of smart agricultural demonstration areas by creating layout plans at the national, provincial, and city levels. Second, to strengthen the research and development of key technologies for smart agriculture, we should focus on special sensors for agriculture and strengthen the research and development of new technologies such as agricultural virtual reality, artificial intelligence, and blockchain. To implement an intelligent transformation and upgrade project for agricultural equipment, a smart agricultural big data platform shall be built, strengthening individualization and intelligent and accurate production management services. Third, it is necessary to establish an improved management system for operation mechanisms for a demonstration area, and innovate investment, construction, and operation modes of this demonstration area. Financial and social capital are encouraged to invest in the construction of the demonstration area through government purchases of services, loan discounts, and cooperation between government and social capital and risk funds.

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