

Developing Ecological Agricultural Engineering to Promote Rural Revitalization in China

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Abstract

Ecological agricultural engineering is a necessary innovation and expansion of China's agricultural engineering science and technology that aims to meet the overall, the whole chain and the coordinated development needs of the whole system for rural revitalization. Focusing on ecological agricultural engineering, this paper introduces its development and early practice and technology, and also discusses its development direction, development path, and important role in boosting rural revitalization. The development of ecological agricultural engineering will play an important role in China's agricultural production practice, agricultural engineering discipline construction and agricultural and rural modernization.

Keywords

Rural Revitalization, Ecological Agriculture, Agricultural Engineering, Ecological Agricultural Engineering

1. Introduction

After more than 70 years of development since the founding of new China, China's agriculture has made great achievements, feeding nearly one-fifth of the population with 9% of the world's arable land and 6% of the world's freshwater resources [1]. Food production and food security have always been the top priority of China's agricultural development. However, China's agricultural modernization has not yet been fully realized, and is still in the transition stage from traditional agriculture to modern agriculture. Moreover, agricultural development faces many challenges, including resource constraints and ecological damage. How to promote the sustainable development of agriculture is a major issue that China's agriculture needs to solve at present.

China has a splendid ancient civilization and was once the most powerful and developed country in the world; agricultural civilization is an important part of Chinese civilization, and advanced agriculture and prosperous rural areas were the true portrayal of ancient Chinese society. In modern history, due to the rise and vigorous development of the industrial revolution in Western countries, China began to lag behind the West. After the founding of New China, the process of modernization and national rejuvenation has been started, of which rural construction is a very important aspect [2] [3]. It is one of the strategic objectives for the Chinese government that rural areas become prosperous again and rural residents enjoy the achievements of modernization through development. In 2018, the State Council issued Strategic Plan for Rural Revitalization [4], which proposed that by 2035, decisive progress should be made in rural revitalization, and agricultural and rural modernization should be basically realized, and then by 2050 agricultural and rural modernization be fully realized, and the goal of rural revitalization with strong agriculture, beautiful countryside and rich farmers be achieved. “Prosperous industry, livable ecology, good general mood of society, effective governance and affluent life” are the overall requirements of rural revitalization, covering political, economic, cultural, and ecological aspects [5]. Among them, prosperous industry needs to improve China’s agricultural strength, and the quality and added value of agricultural products, which is inseparable from the green development of agriculture; for livable ecology, it requires the construction of beautiful villages and the improvement of rural environmental quality, which is the direct embodiment of the ecological connotation of rural revitalization; good general mood of society means promoting the construction of rural humanistic environment, which must include the cultivation of rural residents’ awareness of environmental protection; effective governance requires the realization of scientific management in rural areas, in which ecological and environmental protection will be an essential link; for affluent life, this goal is by no means a goal only related to social and economic benefits, but should be taken into account and realized together with environmental benefit.

Therefore, in order to achieve rural revitalization, the unity of social, economic and ecological benefits must be achieved in agricultural development. This internal requirement is in line with the development connotation of the ecological agriculture emerging in China. The development of agriculture in world has experienced three periods: Primitive agriculture, traditional agriculture and modern agriculture. Among them, modern agriculture has widely applied modern science and technology such as agricultural engineering, inputs of production provided by modern industry, and scientific management methods, which has greatly improved agricultural production efficiency and agricultural productivity. However, the large investment of modern agriculture in pesticides, chemical fertilizers, and electricity has also accelerated the depletion of resources, led to serious damage to the ecological environment and posed a great

challenge to the sustainable development of social economy. In order to solve the problems brought by the development of modern agriculture, the development concept of industrial civilization must be abandoned, which completely focuses on people, while the new idea of the harmonious development between human and natural environment should be adopted, and ecological agriculture that takes economic, social and ecological benefits into account should be developed. Wei Xiuju *et al.* [6] [7] suggested that it should develop the ecological agricultural engineering, which is the agricultural production system proposed to realize ecological agriculture, and the ecological development of agricultural engineering technology on which modern agriculture depends. It has great application potential and broad development space for governing and overcoming the ecological environment problems caused by modern agricultural production mode.

2. Development of Ecological Agricultural Engineering

American scholar H. T. Odum first put forward the definition of “ecological engineering” in 1962, considering that it is “the environmental control of the system dominated by natural energy by using a small amount of auxiliary energy”. In 1971, he also pointed out that “man’s management of nature is ecological engineering”. After the advent of ecological engineering, it is mainly used in the fields of industry, agriculture and environmental protection. Although China’s ecological engineering started in the late 1970s, it has accumulated a lot of simple agricultural ecological wisdom in thousands of years of agricultural history and has a deep tradition with congenital superiority. Therefore, the research in this field soon ranks in the forefront of the world, and Ma Shijun is one of representative scholars.

From another point of view, ecological agricultural engineering is an emerging field formed by the development of agricultural engineering in the direction of ecology. Agricultural engineering is another branch of agricultural science besides agricultural biology and agricultural economics. Agricultural engineering is the general term of basic construction and engineering facilities serving agricultural production and farmers’ life. In terms of scope, it includes agricultural mechanization engineering, agricultural water and soil engineering, agricultural biological environment engineering, rural energy engineering, agricultural electrification and automation engineering, agricultural product processing engineering, and land use engineering. As a discipline, agricultural engineering first emerged in 1907 in the United States. In the 1940s it was introduced into China and developed rapidly in the 1970s, making great contributions to the development of modern agriculture in China. Ecological agricultural engineering came into being to deal with the problems of agricultural environmental pollution and land degradation. It is an innovation and expansion in the field of agricultural engineering.

Ecological agricultural engineering is the ecological development of agricul-

tural engineering. In order to meet the needs of ecological society and agricultural and rural development, ecological agricultural engineering adopts the theory of ecology and system engineering and the technology method of ecological engineering, integrates agriculture, rural area, nature, resource and environment factors, improves the theory and method of agricultural engineering discipline by following the concept of overall, systematic, circular and coordinated development, ensure food security, food safety and ecological security, and comprehensively improve economic, social and ecological benefits to achieve sustainable development of agriculture [6] [7].

The direct goal of ecological agricultural engineering is to develop ecological agriculture, and the fundamental goal is to realize the sustainable development of agriculture. Its center is to make agriculture based on ecology rather than chemistry [8]. Western modern agriculture is based on chemistry, which requires a lot of chemical fertilizers and pesticides, and the use of agricultural machinery also consumes a lot of energy. Although the oil agriculture has brought high efficiency and high yield of agriculture, its cost is the huge damage to the environment and the unsustainable development of agriculture. A research expert on “Agriculture, Rural Areas and Farmers” in China pointed out that ecological development is not only the way out of human civilization, but also the way of getting out of difficulties and entering sustainable development for agriculture [9].

Ecological agricultural engineering is produced to solve the problems of agricultural development. Its development thought and connotation are mainly reflected in the following aspects: First, from the perspective of natural-social-economic composite ecosystem, ecological agricultural engineering applies the ecological principles such as material circulation and energy flow of ecosystem, as well as system scientific methods to carry out overall design and management of agricultural production, so as to make the production process resource-saving and environment-friendly, and at the same time ensure the high quality, safety and high yield of agricultural products. Second, ecological agricultural engineering organically integrates ecological wisdom and modern agricultural engineering technologies, so as to overcome the disadvantages of modern agricultural technology through the application of ecological science achievements, protect the sustainable productivity of agricultural ecosystem through the protection of ecological environment, and make modern agriculture develop towards a green and sustainable direction. Third, ecological agricultural engineering respects the laws of ecology. While promoting the healthy and stable development of agriculture with the three biological attributes of “production, life and ecology”, it will also promote the improvement of the environment in rural areas with the characteristics of “coexistence, symbiosis and sharing” and the improvement of farmers’ life quality [9]. Therefore, it can promote the realization of China’s agricultural and rural modernization at a greater level. Ecological agricultural engineering is an innovation and expansion in the field of agricultural engineer-

ing. Based on agricultural engineering, it combines the principles of ecology and the agricultural engineering science and technology, aiming to achieve the complex goal of giving consideration to economic benefits, ecological benefits and social benefits, which is the core feature of ecological agricultural engineering.

The ecological agricultural engineering was also called as the agricultural ecological engineering in some scholars' study [10]. In fact, although there are some overlaps in the development purpose and implementation path, the concept connotations of the two are not completely the same. Ecological agricultural engineering is put forward based on agricultural engineering, which is the ecological development of agricultural engineering, and belongs to the cross integration of ecological engineering and agricultural engineering in the scope of discipline. Agricultural ecological engineering, put forward based on ecological engineering, has a wider coverage; the ecological engineering processes, methods and measures applied in the agricultural field belong to its scope. See Reference [6] for the analysis between the two.

3. Early Practices and Technologies of Ecological Agriculture/Ecological Agricultural Engineering

As a country with 4000 years of farming history, China has accumulated a lot of excellent traditional agricultural experience, such as rotation, interplanting, returning organic fertilizer to the field, and comprehensive production of mulberry and fishery. They have nested ecological protection measures at different levels and applied ecological principles such as multi-layer and hierarchical utilization of materials and regeneration and recycling to maintain soil fertility. In fact, they are simple spontaneous ecological agricultural engineering [11]. In the middle and late 20th century, with the progress of modern agricultural science and technology such as agricultural engineering, China's agriculture has been vigorously developed. On the basis of traditional agricultural experience and technology, the following ecological agriculture/ecological agricultural engineering models have been developed.

1) Circular agriculture

Circular agriculture is an agricultural mode based on ecological principles and system engineering theory, which meets the requirements of ecological agricultural engineering. Take mulberry-base fish pond in South China and Taihu Lake area as an example. Local farmers dig low-lying fields into fish ponds, and the excavated soil is placed around the fish ponds as the foundation, on which mulberry trees are planted, and fish are fed in fish ponds; mulberry leaves are used to feed silkworms, and silkworm sand and silkworm pupae are put into fish ponds to feed fish, which can also promote the reproduction of plankton in water and provide food for fish; sludge at the bottom of the pond with rich organic matter is used as organic fertilizer for mulberry trees on the foundation. The whole mulberry-base fish pond forms a good closed loop and has outstanding circulation characteristics. In addition to product output, the substances in the

system basically participate in recycling, do not produce any pollution, and have remarkable ecological benefits. At the same time, the nutrient structure of the foundation pond is reasonable and coordinated, the system is stable, and the economic benefits have been optimized to the greatest extent. It is estimated that the output value per unit area and labor income of mulberry-base fish pond are about 2.4 and 3.0 times that of local paddy fields, respectively. In addition, sugarcane-base, flower-base and fruit-base fish ponds also have similar benefits [12].

2) Courtyard ecological agriculture

Courtyard ecological agricultural engineering is an agricultural engineering model with family as unit, courtyard as base and the purpose of improving commodity rate. The courtyard area is generally small, where high-density symbiosis is shown for animals, plants and microorganisms, complex food chain relationships exist among producers, consumers and decomposers, and limited land is used as both production space and living space [12]. This model can make full use of courtyard idle land, rural surplus labor force and idle funds, and there is a typical multi-level recycling of material and energy. Courtyard ecological agricultural engineering is divided into different modes, such as planting and breeding combination mode, three-dimensional cultivation and processing mode, comprehensive production and management mode, such as planting and breeding combination of grape—traditional Chinese medicine crop—fish—cash crop. In space, courtyard ecological agricultural engineering makes full use of the limited space through the principle of complementarity. In terms of time, it skillfully carries out the matching production of different species according to the law of biological production and development. Therefore, it has outstanding intensification, management and three-dimensional comprehensiveness.

3) Ecological agricultural engineering of pest regulation

The application of chemical pesticides is a common measure to prevent diseases and insect pests and ensure stable and high agricultural yield, but it often brings harm to the environment at different degrees and leads to ecological security risks. Biological control ecological agricultural engineering adopts biological methods to carry out comprehensive treatment and reduce or even completely avoid the use of chemical pesticides [12]. Pest ecological regulation is an ecological strategy, such as promoting crop health and soil health on the field scale, setting up the spatial shelter, transfer habitat and overwintering environment for pest natural enemies on the landscape scale, restoring the resistance of the ecosystem to the greatest extent [13], planting plants conducive to natural enemies of pests to build an environmental system with strong natural biological control ability, and releasing natural enemies of pests during their spawning period to reduce the population base of pests.

4) Rural energy ecological engineering

Rural energy ecological engineering is a system of livestock and poultry waste recycling and energy development and utilization, of which biogas engineering is

familiar. Taking Longyou County, Quzhou City, a large livestock and poultry breeding County in Zhejiang Province as an example, pig excreta of local pig farms are collected and stored in anaerobic tanks for centralized fermentation; biogas produced by fermentation is burned for power generation, which is connected to the State Grid to provide power for the domestic electricity of local residents; biogas residue and dry manure are processed into solid organic fertilizer for sale through drying and other processes; biogas slurry generated is transported to the liquid storage tank of planting base and applied in the farmland as organic fertilizer [14]. In this way, possible environmental pollution caused by a lot of excreta in large-scale livestock and poultry breeding is escaped, and the waste is recycled and utilized as resource, so as to realize the win-win of economic, ecological and social benefits.

5) Rural tourism agricultural engineering

China's rural areas are vast. Rural tourism provides an opportunity for the combination of primary industry and tertiary industry, and may become a new way for rural residents to create employment opportunities and increase their income. At the same time, to improve the attraction to tourists, rural tourism can also promote rural areas to improve the beauty of the environment, develop characteristic tourism resources and improve service quality, hence promoting the development of rural areas. According to different element composition and combination mode, rural tourism has a variety of business types, such as agri-tainment, rural home stay, rural boutique hotels and campsites, scenic roads, traditional villages and towns, pastoral complexes, and tourism towns [15]. With the prosperity of social economy and the acceleration of urban-rural integration, rural tourism has become a new growth point and development paradigm of tourism. The development of rural tourism opens up a broad market space for traditional agriculture, and traditional agricultural culture also endows rural tourism with profound original ecological connotation. The two complement each other [16].

6) Multi industry comprehensive ecological engineering

It is the ecological engineering formed by multi industries. Taking the comprehensive ecological engineering formed by agriculture, animal husbandry and fishery as an example, it organically combines planting, aquaculture and bioenergy production, and integrates land production with water production. In this comprehensive agricultural ecosystem with multi-level configuration, crop straw produced by planting industry can be processed to feed pigs and laying hens; pig manure can be put into biogas digester to produce biogas; biogas slurry is rich in nutrients and can be used as organic fertilizer for farmland; biogas residue is used to grow mushrooms or feed earthworms, and residue after harvesting mushrooms and earthworm dung can also be used as fertilizer in farmland. Through comprehensive ecological engineering, the economic benefit can be several times higher than that of a single production system: A variety of foods such as eggs, chick-

ens, pigs and fish can be provided for the market in addition to grain, and the waste of livestock and poultry excreta can be turned into useful resource through biogas fermentation, hence achieving energy self-sufficiency. Therefore, it continuously obtains the best productivity and ecological and economic benefits.

4. Development Direction of Ecological Agricultural Engineering for Rural Revitalization

In the background of rural revitalization, developing ecological agricultural engineering science and technology is in line with the requirements of the times and the development trend of agricultural engineering discipline, showing the following main development directions.

4.1. Green Development to Meet Requirements of Rural Revitalization

At present, China's agricultural production is facing serious ecological problems: Resource depletion, land quality degradation, aggravation of agricultural environmental pollution, and so on. According to relevant data, accounting for 1/3 - 1/2 of the country's total pollution, China's agricultural pollution has become an important pollution source of soil, water and air, and poses a serious threat to the sustainable development of agriculture and rural economy [17]. At the same time, the deterioration of agricultural ecological environment and the excessive use of pesticides and chemical fertilizers also lead to the quality and safety problems of agricultural products.

In the future, China's agricultural development should not only be satisfied with the provision of food and agricultural primary products, but also ensure the quality of agricultural products and the safety of agricultural production environment. Therefore, it is necessary to pay attention to the high-quality and sustainable development of agriculture. It is also an important main line of China's agricultural supply side structural reform from over reliance on resource consumption and focusing on meeting the demand of quantity to pursuing green ecological sustainability and paying more attention to meeting the demand of quality [18].

Therefore, developing ecological agriculture and taking the road of green development for China's agriculture is the historical mission in the new era of agricultural development, the inevitable choice under the era topic of rural revitalization, and the key link to achieve the goal of agricultural and rural modernization in 2035. The development direction of ecological agricultural engineering is to realize ecological agriculture, which enhances agricultural productivity and improves agricultural output, and protects the ecological environment from damage at the same time. Therefore, ecological agricultural engineering meets the internal requirements of green development and ecological revitalization in the process of agricultural modernization, and is bound to make greater and sustainable contribution to China's agriculture.

4.2. Integrating the Essence of Traditional Agricultural Science and Technology with Modern One

There are obvious disadvantages in modern agriculture in developed countries such as the United States. For example, after a large amount of chemical fertilizer is invested, the soil is easy to harden, the soil fertility continues to decline, and agriculture cannot develop sustainably. Practice has proved that modern agriculture based on oil is not the development direction of China's agriculture. In fact, western countries are also seeking to get out of the dilemma of agricultural development, which is the reason why various alternative agricultures appear. Moreover, as early as 100 years ago, American scholars once set their eyes on the ancient East and tried to seek the outlet and enlightenment of agriculture from the oriental traditional agriculture that lasted for thousands of years. Franklin H. King, a pioneer of the American Organic Agriculture Movement, highly praised the rotation of legumes and other crops to enrich the soil in China after his on-the-spot investigation [19].

In fact, many agricultural engineering technologies in China already contain a certain awareness of ecological protection, yet such awareness is relatively simple and primitive. However, such agricultural ecological wisdom is worth exploring and developing for the agriculture in China. If China's traditional agriculture experiences are combined with modern advanced agricultural technology, the quality of ecological environment will be maintained and protected to the greatest extent while agricultural productivity is developed. Therefore, with the increasing attention to the quality of ecological environment, there is a need to systematically integrate the ecological concept into the framework of agricultural engineering. To comb the concept of ecological protection, highlight and emphasize the role of ecological factors in agricultural engineering science, and integrate the research results of agricultural engineering and ecological engineering, making the scattered and embryonic ecological agricultural engineering discipline to become systematization, can not only expand the connotation of agricultural engineering science itself, but also help to use agricultural engineering technology and methods in a more ecological-protection way.

4.3. Deep Integration of Ecological Protection Technology and Agricultural Engineering Technology

As an important part of the transformation of agricultural science and technology, agricultural engineering science and technology is the technical support and guarantee to realize agricultural modernization and rural revitalization. For example, at the beginning of reform and opening up, China Agricultural Engineering Design and Research Institute led the application of fuel forests, firewood stoves, biogas, wind power, small hydropower and solar energy, making agricultural engineering technology a driving force for agricultural development. In the new stage of agriculture and rural development, agricultural engineering science and technology must fully examine the characteristics of China's agri-

cultural and rural areas according to the requirements of rural revitalization strategy, enrich and expand its own content, and make itself better meet the needs of rural revitalization.

The proposal of rural revitalization in contemporary China not only brings good development opportunities for agricultural engineering science and technology, but also poses great challenges to traditional agricultural engineering. Each professional field of agricultural engineering follows the concept of ecological protection and sustainable development to a certain extent, but lacks systematic concept, design, planning and management measures for ecological agricultural engineering. The existing environmental protection measures of agricultural engineering are partial, phased and incomplete, which are difficult to meet the theoretical and technical needs of comprehensiveness, whole chain and overall system coordination for rural revitalization. The development of ecological agricultural engineering can effectively make up for the shortcomings of agricultural engineering technology in rural revitalization, and make it better adapt to and meet the major needs of rural modernization for engineering technology.

5. Development Path of Ecological Agricultural Engineering for Rural Revitalization

5.1. Integration and Coordinated Development of Multidisciplinary Principles and Technologies

Ecological agricultural engineering itself is a cross science, which focuses on the compound goal of economic, ecological and social benefits. Therefore, its development should integrate the principles and technologies of in agronomy, ecology, biology, engineering, environmental science, economics, and management sciences (Figure 1), such as ecological principles, system theory, engineering technology, and fully absorb and introduce cutting-edge technologies such as

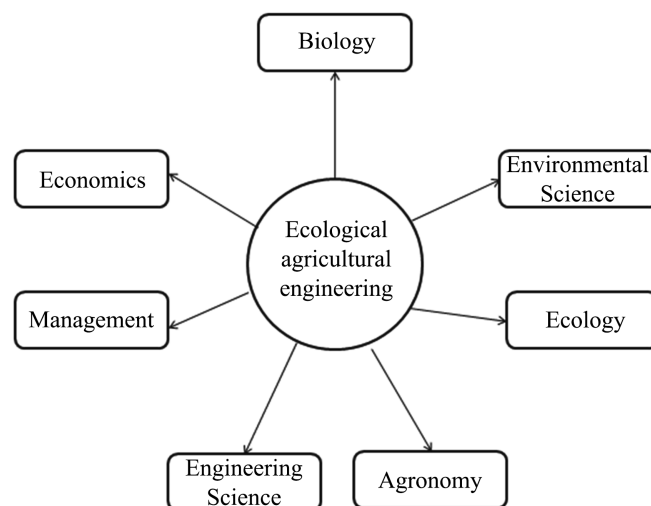


Figure 1. Knowledge structure of ecological agricultural engineering discipline.

UAV (unmanned aerial vehicle) and remote sensing technology. Only through the organic integration and coordinated development of multiple disciplines, can ecological agricultural engineering give full play to its own advantages, help rural revitalization and promote the realization of agricultural modernization in the process of ecological civilization construction.

5.2. Promoting Standardization of Ecological Agricultural Engineering

The future development of ecological agricultural engineering should follow the development frontier of ecological agriculture in the world, and formulate the international cooperation plan for the development of ecological agriculture; strengthen the high-level research, strategic planning and scheme design of developing ecological agriculture and promoting rural revitalization; formulate the development standards of ecological agriculture in line with national conditions and the standards for developing ecological agriculture to promote rural revitalization, including the standards for categories, systems and distinguishable secondary industries of ecological agriculture, the accounting standards for the value of ecological agriculture, and the target framework, accounting framework and organizational framework for developing ecological agriculture to promote rural revitalization; in addition, it is necessary to increase public investment, provide model demonstration and guidance, summarize the successful experience of different models, and reveal the common development law or trend.

5.3. Changing Isolate Technology to Form Highly Systematic Mode

There are some ecological agricultural engineering in China, such as the foundation pond mode in South China and the compound system of agriculture, forestry and animal husbandry in Northwest China. However, many technologies are inherited from the local traditional farming. Although full of ecological wisdom, they are spontaneously adopted by farmers to a large extent and are isolate and decentralized production modes. Therefore, they fail to give play to their ecological advantages and production potential to the greatest extent. It is necessary to summarize and optimize the modes of representative ecological agricultural engineering in different regions, and popularize them with highly systematic and organized modes in suitable areas. Changing decentralized production mode to highly organized mode helps to give play to the regional scale effect of each mode, and release its productivity to the greatest extent.

5.4. Developing Practical and Theoretical Research Simultaneously

At the beginning of its development, agricultural engineering was positioned as an applied discipline. However, for a simple applied discipline, it is difficult to have further development after completing its main service objectives. Therefore, it should not only stay in applied research, but should deeply explore its internal relationship with related disciplines, especially the relevant principles of

ecology. Agriculture has the attribute of natural symbiosis with natural resource elements, which is its own particularity [9]. Therefore, it is necessary to carry out disciplinary research based on the characteristics of ecological science and agronomy, and besides the internal laws of agricultural production, explore the complex relationship between agricultural elements and various environmental factors, which is the essence of ecology. In fact, the ecology refers to the relationship between organisms and their living environments. For a discipline, it must take science rather than application as the starting point, follow the discipline development law, carry out scientific and technological innovation on cutting-edge focus issues, and enrich the discipline content in theory. Only in this way can a discipline maintain its vitality, and promote its own sustainable development.

6. Ecological Agricultural Engineering Realizes the Goals of Rural Revitalization in China

6.1. Ecological Agricultural Engineering Provides Basis for Sustainable Development of Agriculture

Green and sustainable ecological agriculture is a new mode that adapts to the sustainable and healthy development of China's agriculture [20]. Ecological agricultural engineering attaches great importance to the common realization of economic, ecological and social benefits, and is ultimately oriented to the sustainable development of agriculture. Sustainable development aims to coordinate the relationship between life system and supporting environment, so that resources and environment can always support the good operation of life system. To achieve this goal, it is necessary to follow the principle of material recycling, realize the recycling and sustainable utilization of resources, and exchange the minimum cost for the maximum development [12]. However, in the process of agricultural development, there is always a great conflict between "development" and "protection". The rapid growth of China's comprehensive agricultural productivity is largely at the expense of the ecological environment, and historical experience and lessons tell us that China can no longer follow the old path of pollution first and treatment afterwards in developed countries [21]. Ecological agricultural engineering is an ecological engineering in the field of agriculture. Its connotation and attribute fit with sustainable development very much, and both of them have a high degree of consistency [22]. In order to truly realize agricultural sustainable development, it is inevitable to choose the ecological agricultural engineering technology system based on ecology and take the road of green development. Therefore, ecological agricultural engineering for ecological agriculture construction will provide the basis for the sustainable development of agriculture.

6.2. Ecological Agricultural Engineering Expands Effective Channel for Rural Environment Improvement

The high mechanization of modern agriculture is driven by oil, and a large

amount of chemical fertilizers and pesticides are also made of oil and natural gas. This kind of “oil agriculture” has a high dependence on non-renewable energy resources, and makes a predatory management of land, which brings the decline and even exhaustion of land productivity, environmental pollution and deterioration, and the enrichment of toxic and harmful substances in agricultural products. Ecological agricultural engineering takes the road of ecological green development. Many studies have shown that significantly reducing the amount of chemical fertilizer, or relying entirely on farm fertilizer or organic fertilizer without chemical fertilizer, can ensure crop production not to reduce and even achieve higher yield, effectively reduce greenhouse gas emissions [9] [23], and make carbon sequestered in soil in the form of organic matter, becoming a contributor to fertility enhancement. For example, for every 10 kg/hm² reduction of nitrogen fertilizer in farmland in China, the emission of greenhouse gases from food crops will be reduced by 8.1 million tons of CO₂ equivalent per year [24]. At the 75th United Nations General Assembly on September 22, 2020, Chairman Xi Jinping announced: CO₂ emissions in China will peak by 2030 and strive to achieve carbon neutrality by 2060. Therefore, the ecological development of agriculture can fix carbon and reduce carbon emissions, which agrees to China’s “low-carbon” development idea and helps to achieve the goal of carbon peak and carbon neutralization. In addition, resource utilization of agricultural wastes such as straw and livestock manure can be realized through transformation technology, and energy crops such as cassava, sweet sorghum and switchgrass can provide biomass energy [25]. With both energy and resource attributes, biomass can effectively be used to deal with the energy crisis caused by the gradual depletion of energy resources, and is an important substitute for fuels and raw materials of fossil in the future [26].

6.3. Ecological Agricultural Engineering Enhances Farmers’ Income

Agricultural product processing, rural transportation, rural tourism and leisure agriculture, and agricultural product e-commerce are all important aspects of the integrated development of rural three industries, which can accelerate the transformation and upgrading of agriculture, solve the outstanding problems of low added value of agricultural products and high transaction costs, effectively expand the employment channels of rural residents, and increase farmers’ income. The agricultural product processing industry covers a wide range of agricultural products, including grain, oil, as well as fruits, vegetables, livestock products and aquatic products, which are closely related to people’s lives. In 2019, there were 81,000 agricultural product processing enterprises above designated size nationwide, absorbing more than 30 million farmers to work; the operating income of agricultural product processing industry above designated size accounted for 21.4% of the main business income of the industry above designated size with 22.4 trillion yuan [27]. The combination of agricultural trans-

portation industry and rural e-commerce can expand the popularity and sales radius of agricultural products by improving rural network construction and building an Internet sales platform for agricultural products, which therefore can complete the process from production to consumption faster, and also drive the development of local logistics, warehousing and other related industries. In 2021, rural online retail sales reached 2.05 trillion yuan, agricultural products online retail sales reached 422.1 billion yuan, and rural online merchants and online stores reached 16.325 million [28].

6.4. Ecological Agricultural Engineering Adds Strength of Agricultural Science and Technology for Rural Revitalization

Ecological agricultural engineering integrating ecological principles and system science will have a profound impact on the agricultural science and technology system [21]. With the development of modern agricultural science, mechanization and automation have made people get rid of heavy agricultural work and doubled labor productivity; the innovation of breeding technology and the investment of pesticides and chemical fertilizers have greatly increased the unit yield of grain; transgenic technology has brought great potential for increasing grain production and created a miracle of rapid development of agricultural productivity. However, modern agricultural science and technology has also brought many serious problems, such as environmental pollution, ecological damage, and food safety. The ecological development will provide antidotes to many disadvantages of modern agriculture and provide a way out for the plight of agriculture [9]. Ecological agricultural engineering develops based on the relationship between biology and environment. Combined with biological attributes, from the perspective of integrity and system, ecological agricultural engineering follows and makes rational use of the objective law of material circulation and energy flow in the agricultural system, so as to make circular and sustainable use of resources and energy, and realize the three in one of economic, ecological and social benefits in agricultural production. In terms of agricultural science and technology system, it will guide and open up a new technological pattern. The resource recycling, green and pollution-free technology will obtain development opportunities, show vigorous vitality, and obtain strong support in terms of funds and policies.

7. Conclusions

Ecological agricultural engineering integrates modern scientific and technological achievements with the essence of traditional agricultural technology, adapts to the internal requirements of China's contemporary green development and ecological revitalization, inherits and carries forward the simple ecological wisdom, conforms to the development trend of international agricultural engineering disciplines, and breaks the difficult problems of agricultural development in the context of China's rural revitalization. Ecological agricultural engineering is

the cornerstone of helping agriculture to move towards sustainable development, and will have a profound impact on agricultural science and technology system, and can also help China to achieve the goal of carbon peak and carbon neutralization and deal with the contemporary energy crisis. The development of ecological agricultural engineering will play an important role in the practice of agricultural production, the discipline construction of agricultural engineering and the construction of agricultural and rural modernization in China.

The ecological agricultural engineering is a solution to the agricultural development problems in China. In the context of rural revitalization, ecological agricultural engineering needs to carry out green development, integrate modern scientific and technological achievements with the essence of traditional agricultural technology, and make a deep integration of ecological protection technology and agricultural engineering technology. In terms of development path, ecological agricultural engineering should integrate and coordinate the development of multi-disciplinary and multi-field principles and technologies; formulate a series of standards for the development of ecological agriculture and promote the standardization of ecological agricultural engineering; change the isolate technology to form a highly systematic and organized mode; and emphasize both applied research and theoretical research. The development of ecological agricultural engineering can realize the goals of rural revitalization: It provides the basis for sustainable development of agriculture, expands effective channels for rural environmental governance, enhances farmers' income, and adds strength of agricultural science and technology for rural revitalization. The development of ecological agricultural engineering will certainly play an important role in the great cause of comprehensively promoting the vitalization of rural areas in China, and in the agricultural production practice, the construction of agricultural engineering discipline, and the construction of agricultural and rural modernization in China.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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