

Agricultural Eco-Efficiency : Challenges and Progress

Subjects: Area Studies

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The research on agricultural eco-efficiency has become an important point to deeply understand the interaction between ecological and environmental conditions and socio-economic factors as well as realize the coordinated development of agricultural economic development and environmental protection. (1) Background: This paper attempts to provide scientific support for the healthy and stable development of the agricultural economy and the sustainable development of ecological agriculture. (2) Methods: From a comprehensive perspective, this paper systematically analyze the overall situation, development trend, key fields, and hot fields of agricultural eco-efficiency in the past two decades. It consists of two complementary parts, including systematic quantitative literature review (based on CiteSpace) and traditional literature review. (3) Results: Agricultural eco-efficiency has evolved significantly with the popularization of agricultural machinery and the wide application of science and technology in the field of agricultural ecology. Its future development relies on the advances in our knowledge on theories and hypothesis, evaluation methods, impact on “socio-economic ecological” system, and drivers and regulation of agricultural eco-efficiency. For each of these fields, we find that challenges still exist. At present, the quantitative methods and index selection are not unified. We should deeply analyze the internal and external driving force of the development and change of ecological efficiency by constructing a complete theoretical framework for the research of agricultural ecological efficiency. At the same time, new technologies and methods are needed to evaluate agricultural eco-efficiency, and a balanced consensus between the improvement of agricultural eco-efficiency and the improvement of the ecological environment should be formed through empirical research.

Keywords: agricultural eco-efficiency ; sustainable development ; literature review ; progress and prospect

1. AEE Research from the Perspective of Low Carbon

Low-carbon agriculture reduces carbon emissions as much as possible in the process of agricultural production and brings into full play of the function of agricultural carbon sink, that is, “increasing the carbon sink and reducing carbon emission”. The ultimate goal is low energy consumption, low emission, high carbon sink. and high efficiency in the process of agricultural production. At present, AEE research is scattered to a certain extent, only focusing on the evaluation of ecological efficiency. Different from the industrial system, the agricultural system has dual functions of carbon emission and carbon sink. Agricultural production activities will produce a large number of greenhouse gas, but at the same time, the agricultural ecosystem also has a strong carbon sink function ^[1]. Compared with industrial carbon emissions, sources of agricultural carbon emissions are diverse, which can be summarized into the following three aspects: firstly, the input of agricultural means of production, carbon emissions generated in the process of agricultural energy consumption, and agricultural waste treatment; secondly, the amount of carbon sequestration in farmland ecosystem, that is, to measure the carbon sequestration function of crops; and third is the carbon emissions from breeding animals and livestock ^{[2][3]}. Because agricultural production activities have obvious external and internal characteristics, it is of great significance to integrate agricultural carbon emissions and carbon sinks into the agricultural efficiency evaluation system and investigate AEE from the perspective of low carbon. On the one hand, farmers' excessive input of chemical fertilizers and pesticides in the process of agricultural production or the use of wrong farming methods will lead to an increase in carbon emissions. If the environmental costs caused by agricultural carbon emissions are internalized, the level of agricultural output will decline significantly. On the other hand, if we do not consider carbon sequestration produced by crops, grasslands, and forests, we will underestimate agricultural efficiency. It can be seen that carbon emission and carbon sink are important aspects of negative and positive externalities of agricultural production activities. AEE research should be comprehensively and objectively evaluate the AEE from the perspective of low carbon, taking the carbon emissions generated in the process of agricultural production as unexpected output and agricultural carbon sink as ecological output ^[4].

2. The Impact of Farmland Ownership Confirmation Reform on AEE

By improving the stability, security, and integrity of land rights, the confirmation of agricultural land rights significantly reduces the input and use of chemical fertilizers and pesticides and helps to promote the ecological protection of cultivated land aiming at the reduction of chemical fertilizers and pesticides. Cultivated land is the material basis carrier to achieve sustainable agricultural development and maintain national food security. The foundation of cultivating land ecological protection is its property right protection. As the vivid practice of cultivated land property right protection and the basic content of agricultural land property right reform, agricultural land right confirmation has special significance for cultivated land ecological protection ^{[5][6]}. However, whether confirmation of agricultural land rights is conducive to the ecological development of agriculture remains to be tested by experience. On the one hand, the property rights of farmland owned by farmers are no longer incomplete and fuzzy, and farmers will be willing to make decisions to reduce the investment of chemical fertilizers and pesticides ^[6]. On the other hand, in view of agricultural profits, if farmers expect that reducing the corresponding input cannot reach the expected output level, farmers are likely to temporarily increase the input of chemical fertilizers and pesticides ^[7]. Since the usual time of chemical fertilizers and pesticides is earlier than the implementation time of their policies, the expected impact of this index is unknown. In general, after the reform of rural land ownership, the right boundary of rural land property rights is clearer, the land rights and functions are more complete, and the protection of rights and interests is more powerful, which is conducive to enhancing farmers' awareness of rural land protection. The way of agricultural land ownership confirmation directly affects the use of chemical fertilizers and pesticides in the process of agricultural production and is an important factor affecting AEE.

3. AEE Temporal and Spatial Characteristics and Influencing Factors

Firstly, the temporal evolution trend and spatial distribution characteristics of AEE were analyzed, and the temporal and spatial characteristics of AEE in China were discussed. It was found that from the perspective of regional differences, there is a regional imbalance in the growth of AEE. The high-efficiency area of AEE is still dominated by the eastern coastal provinces, but it tends to transfer to the central and western regions ^{[8][9]}. From the perspective of time evolution, the overall AEE in China shows a fluctuating upward trend, and there are some inter-provincial differences ^[10]. The government should strengthen policy guidance, promote the diffusion of efficient production factors in the eastern region to the central and western regions, and gradually improve the AEE of medium- and low-efficiency areas. It can be seen that AEE is related to economic development and the overall requirements of industrial structure transformation and upgrading as well as the location conditions, resource endowment, and policy implementation effectivity and economic development level of each province.

In addition, the important driving factors of the temporal and spatial evolution of AEE were discussed from the overall national overall level and regional level. From the driving factors, the confirmation of agricultural land rights, the level of financial support for agriculture, per capita agricultural GDP, agricultural production capacity, agricultural machinery density, agricultural scale level, agricultural disaster rate, and industrialization and urbanization level play a driving role in AEE. From a national perspective, the ecological development of agriculture should start with the development of agriculture itself, make use of new environmental protection technologies, and clarify the ownership of land property rights ^[11]. From a regional perspective, all regions make full use of their respective regional advantages to develop ecological agriculture according to local conditions. Among them, the technological progress index contributes the most to the improvement of AEE ^[12]. Therefore, the key to improving AEE is to promote agricultural technology progress and management innovation and promote the transformation of extensive agricultural management mode to ecological energy consumption and intensive energy-consumption path.

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