How to Develop Low-carbon Agriculture in China?

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Abstract With the advent of low-carbon economy nowadays, the development of agriculture is necessary to adapt to the situation of global economic development, and transform the agricultural development models. This paper firstly gives an overview of low-carbon economy and low-carbon agriculture, and then points out the possibility of developing the low-carbon agricultural economy in China, and describes the ways to develop the low-carbon agricultural economy. Finally, this paper puts forth the corresponding recommendations for the development of the low-carbon agricultural economy.

Key words Low-carbon agriculture (LCA), Circular agriculture, Post-modern agriculture, Non-petroleum agriculture

1 Introduction

In the 21st century, the global warming caused by the greenhouse effect is becoming a common challenge faced by mankind. Climate change poses a serious threat to sustainable development of the ecological environment and human society, causing widespread concern in the international community. In 2003, the British government released the Energy White Paper 2003: Our Energy Future-Creating A Low Carbon Economy, first proposing the "low carbon economy" concept. The commitment of the London G20 summit in 2009 to economic recovery and low carbon transition, as well as the controversy of Copenhagen Climate Conference, has promoted the dissemination of the "low carbon economy" concept worldwide. The academic world has not yet given a uniform definition of "low-carbon economy" at present, but based on various definitions, it is generalized that a low-carbon economy (LCE), low-fossil-fuel economy (LFFE), or decarbonised economy is an economy based on low carbon power sources that therefore has a minimal output of greenhouse gas (GHG) emissions into the environment biosphere, but specifically refers to the greenhouse gas carbon dioxide. GHG emissions due to anthropogenic (human) activity are increasingly either causing climate change (global warming) or making climate change worse. Scientists are concerned about the negative impacts of climate change on humanity in the near future. Nations may seek to become low-carbon or decarbonised economies as a part of a national climate change mitigation strategy. A comprehensive strategy to mitigate, if that is possible, climate change is carbon neutrality and geoengineering. The aim of a LCE is to integrate all aspects of itself from its manufacturing, agriculture, transportation, and power-generation, *etc.* around technologies that produce energy and materials with little GHG emission, and, thus, around populations, buildings, machines, and devices that use those energies and materials efficiently, and, dispose of or recycle its wastes so as to have a minimal output of GHGs. Furthermore, it has been proposed that to make the transition to an LCE economically viable we would have to attribute a cost (per unit output) to GHGs through means such as emissions trading and/or a carbon tax. Since agriculture accounts for a substantial proportion of the global fossil energy consumption and it is one of the major sources of greenhouse gas emissions. Meanwhile, crop can absorb and fix the carbon dioxide in the atmosphere through photosynthesis, so it has carbon sink function. In the area of agriculture, the promotion of energy-saving and bio-sequestration technologies and development of biomass energy and renewable energy technologies can transform traditional agriculture into the new LCA with new features of low energy consumption, low emission and low pollution. LCA (Low-carbon Agriculture) means that the agricultural production reduces dependence on fossil fuels, and takes new roads of organic, ecological and efficient agriculture. It is also known as non-petroleum agriculture or post-modern agriculture. Modern agriculture is based on the fossil fuels, and fertilizers and pesticides are the pillars of modern agricultural development, having made great contribution to solving the problem of human food, however, the high energy consumption and high pollution of fertilizers and pesticides affects the soil's organic composition, crop pesticide residues and food safety, and the production of fertilizers and pesticides need to consume a large amount of fossil energy, thereby producing large amounts of carbon dioxide emissions. Therefore, in the coming era of LCE, agriculture has also entered into a period of development of modern agriculture, namely the era of low-carbon agriculture or non-petroleum agriculture.

2 The possibility of developing LCA in China

Laws of economic development show that only when the economic development of a country or region enters the middle stage of industrialization can the agricultural growth mode have necessity and possibility of changing. At present, China has been in the middle stage of industrialization, and the per capita GDP has been more than 1200 US dollars, reaching the income level of middle-income

Received: January 24, 2015 Accepted: March 10, 2015

Supported by Business Management Cultivation Discipline of Southwestern University Rongchang Campus.

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level countries. The share of agriculture in GDP is close to the level of moderately developed countries. Engel coefficient of urban residents drops to below 37% , and the market demand for agricultural products declines, but it poses higher requirements on the quality of agricultural products. The proportion of urban population increases from 18% to more than 40% , and the proportion of non-farm working population increases from 30% to more than 50% . In response to the reduction of agricultural labor and high product quality requirements, it is necessary to improve agricultural productivity and agricultural production, to meet the growing food consumption of non-agricultural population and respond to dwindling arable land. According to the international situation and the objective requirements of China's development, it has had the conditions for the transformation of agricultural development pattern, and the pattern transformation is the best choice to solve the existing problems. China's agricultural development should also use LCA to replace HCA (High-carbon Agriculture) and LCA is just the biodiversity agriculture. The industrialized agricultural process poses a threat to biodiversity. The farmland reclamation reduces natural vegetation and the use of pesticides destroys species diversity. The chemical fertilizer causes environmental pollution, and thus also causes loss of biodiversity. If the concept of carbon economy is used to measure, this agriculture can be said to be a HCA. The way to change HCA is to develop biodiversity agriculture. The biodiversity agriculture is a LCA in a sense, because it can avoid the use of pesticides, fertilizers, *etc.*

3 The path of developing LCA and transforming agricultural development mode

3.1 The development of post-modern agriculture China's agricultural development should improve the use efficiency of the limited resources and reduce dependence on investment, that is, it is necessary to develop post-modern agriculture. Only when the development of post-modern agriculture is accelerated can the constraints of resources and environment be broken through and the land productivity and resource utilization rate be improved. Since 2004, Document NO. 1 of the Central Government has paid close attention to issues concerning agriculture, and determined the basic idea of the development of modern agriculture as using modern material conditions to equip agriculture, using modern science and technology to transform agriculture, using modern industrial system to improve agriculture, using the modern business form to promote agriculture, using modern development concept to lead agriculture, cultivating new farmers to develop agriculture, improving the level of agricultural irrigation, mechanization and informationization, improving land productivity, resource utilization and agricultural labor productivity, and enhancing agricultural quality, efficiency and competitiveness. The process of building modern agriculture is the process of transforming traditional agriculture and constantly developing rural productivity, and also the process of transforming the agricultural growth mode and promoting the further development of agriculture.

3.2 The development of circular agriculture The contradiction between people and land is prominent in China, and the efficiency of agricultural production is low, so it is necessary to accelerate the transformation of agricultural development mode and develop the agricultural circular economy. The development of circular economy is an important way to build a resource-saving and environment-friendly society and achieve sustainable development. Circular agriculture is a new model of development and a new way of agricultural economic growth to achieve coordinated development of population, resources and environment. Through the establishment of cycle mechanism "agricultural resources → agricultural products →agricultural waste recycling", it aims to achieve the coordination between economic development and ecological balance, and realize low resource consumption, low waste emission, and high material and energy use in agricultural production. The development of circular agriculture is a real choice to solve agricultural resource shortages and environmental degradation.

3.3 The development of non-petroleum agriculture and organic agriculture Organic agriculture is a form of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control. Depending on whose definition is used, organic agriculture uses fertilizers and pesticides (which include herbicides, insecticides and fungicides) if they are considered natural (such as bone meal from animals or pyrethrin from flowers), but it excludes or strictly limits the use of various methods (including synthetic petrochemical fertilizers and pesticides; plant growth regulators such as hormones; antibiotic use in livestock; genetically modified organisms; human sewage sludge; and nanomaterials.) for reasons including sustainability, openness, independence, health, and safety. Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. The development of organic agriculture can also speed up the ecological control and restoration in the ecologically sensitive and fragile areas, and organic agricultural industry is a labor-intensive industry. The development of organic agriculture can create more jobs to solve the problem of employment in rural areas. The organic products meet the needs of the international market, and increasing the exports can bring good economic benefits to farmers. The organic products have great potential for adapting to climate change.

3.4 The development of ecological agriculture Ecological agriculture is the act of farming using principles of ecology, the study of relationships between organisms and their environment. It has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term". Ecological agriculture can be understood as an ecosystem approach to agriculture. Practices that can cause long-term damage to soil include excessive tilling of the soil and

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economy in Inner Mongolia, increase policy and financial support, and use farming and animal husbandry subsidies and insurance to enhance the enthusiasm for production and ensure the supply of agricultural and livestock products. (ii) It is necessary to continue to adjust and optimize the internal structure of the agricultural economy, consolidate the dominance of farming and animal husbandry economy, accelerate the development of forestry and fishery economy, and efficiently combine the farming, animal husbandry, forestry and fishery, to make agricultural industry structure more reasonable and advantages of agricultural economy more obvious. (iii) It is necessary to reasonably guide the development of various industries within animal husbandry, make dairy product and beef and mutton industry become the leading industry, and make the egg, pig and cashmere industry become the characteristic competitive industry.

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irrigation without adequate drainage. Long-term experiments have provided some of the best data on how various practices affect soil properties essential to sustainability. The key of construction of ecological agriculture lies in the selection of appropriate mode of ecological agriculture through evaluation and design. The development of ecological agriculture can help to fully use a variety of land resources, reduce the area of bare ground, prevent soil erosion and desertification, mitigate floods and storms, improve agricultural productivity and land and resource utilization rate; increase rural incomes and provide new channels of employment; provide agricultural products with comparative advantage, break trade barriers and increase agricultural exports.

3.5 The development of urban agriculture The agricultural development mode should be transformed to constantly upgrade and optimize agricultural structure, and develop multifunctional agriculture. Agriculture has not only the food security function, but also the functions of material supply, ecological protection, tourism and leisure. Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping, and horticulture. These activities occur in peri-urban areas as well. Urban agriculture can reflect varying levels of economic and social development. In the global north it often takes the form of a social movement for sustainable communities, where organic growers, 'foodies', and 'locavores' form social networks founded on a shared ethos of nature and community holism. These networks can evolve when receiving formal institutional support, becoming integrated into local town planning as a 'transition town' movement for sustainable urban development. In the developing south, food security, nutrition, and income generation are key motivations for the practice. In either case, more direct access to fresh vegetables, fruits, and meat products through urban agriculture can improve food security and food safety. The development of urban agriculture can provide a natural leisure environment for the urban residents to meet people's growing demand for getting close to nature. It can also promote new rural construction, increase farmers' income, improve the rural environment, promote coordinated urban and rural development and increase employment.

4 Recommendations for LCA development

4.1 Developing resource-conserving agriculture Full use of the residual energy in agriculture and reasonable use of crop straw resources can help to prevent environmental pollution and fully utilize resources. For example, we can use feed, fertilizer and gasification technology to produce flammable gas under high temperature, high pressure and anaerobic conditions, and we can also use straw to produce ethanol fuel.

4.2 Developing environment-friendly agriculture It is necessary to greatly reduce the application rate of fertilizer and pesticides, mitigate the dependence of agricultural production process on fossil fuels, and take the road of organic and ecological agriculture. For example, we can use manure or compost as an alternative to chemical fertilizers, and improve soil organic matter content; return crop straw to farmland to increase soil nutrients and reduce runoff infiltration; adopt the rotation of crops and introduce earthworms and microorganisms to expand the plant roots' nutritional capacity.

4.3 Developing and promoting the use of new energy It is necessary to promote solar energy and biogas technologies. Popularizing the solar collectors in rural areas is an effective way to develop low-carbon rural areas. In the large-scale livestock breeding, we can use animal feces to produce biogas and obtain biomass energy. It is necessary to transform the development mode of agricultural economy, vigorously promote agricultural economic restructuring and optimization, focus on independent innovation capacity of China's agriculture, and improve the energy-saving and environment-friendly levels of agriculture.