Practical Model and Countermeasures for the Development of Ecological Circular Agriculture in Zhejiang Province, China

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Abstract Development status and five principal practice modes of ecological cycling agriculture are introduced, such as the quantitative reduction mode with the characteristics of fertilizer reduction and clean production, the ecological chain connection and conversion mode including the combination of farming and grazing and the new mode of farming, the agricultural waste recycling mode with biogas as a link and the comprehensive utilization of waste, quality enhancement mode of agricultural products, and eco-cycle mode of agricultural park. Based on the analysis of the socio-economic characteristic environment of these modes, corresponding policy suggestions are put forward in order to promote the development of circular agriculture, such as improving the macro-control mechanism led by the government, promoting the construction of technological innovation system of ecological circular agriculture, and creating the atmosphere for circular agriculture development.

Key words Ecological circular agriculture, Development pattern, Zhejiang Province, China

Ecological circular agriculture is a modern agricultural development pattern using the concept of sustainable development, circular economy theory, and ecological engineering method to save energy resources and to realize environmental protection by the means of scientific and technical innovation, mechanism innovation and system innovation. It follows the direction of clean production, waste utilization and products safety supply by integrating the traditional agriculture to achieve the coordinated development of ecological, economic and social benefits[1]. Zhejiang Province is densely populated with relatively small land area. The per capita cultivated land is less than 0.033 hectare, which is only 1/3 of the level of national average. The amount of the water resource occupation per capita is 2008 cubic meters with uneven temporal and spatial distribution, which is less than the national average of 2 200 cubic meters. With the rapid development of industrialization, urbanization and agricultural modernization, water pollution, air pollution, solid waste pollution and urban waste pollution beome the major obstacles in building a harmonious society in Zhejiang Province. Ecological environment in rural areas is facing tremendous pressure. The resource constraints and the environmental carrying pressures on agriculture become more and more prominent. The severe reality determines that the agricultural development in Zhejiang Province must follow the sustainable development road of circular usage, resource intensive development, energy saving and emission reduction[2]. At present, Zhejiang Province is at the critical period of maintaining growth and promoting transformation. There is urgent demand for the acceleration of the transformation of agricultural development pattern. And it is of great practical significance to vigorously promote the development of ecological circular agriculture[3].

1 The main mode of ecological circular agriculture in Zhejiang Province

After putting forward the strategic decision to build an ecological province in the year 2002, areas in Zhejiang Province have focused on the construction of high-efficient ecological agriculture, and have formed a series of technical patterns, farming systems and the successful practices of ecological circular agriculture with Zhejiang characteristics, which promotes the sustainable and healthy development of efficient ecological agriculture and has laid a good foundation for the overall implementation of ecological circular agriculture.

1.1 Reduction pattern This kind of circular agricultural development pattern is mainly reflected in the absolute or relative reduction of inputs in agricultural production, such as the land saving, water saving, fertilizer saving and medicine saving. The input reduction of agriculture is achieved through improving the use efficiency or the quality of external inputs[4].

1.1.1 Disease control by fertilizer and drug reduction. According to the development requirements of "low input, high quality and high efficiency" in ecological circular pattern, chemical fertilizers, pesticides, veterinary drugs, feedstuffs and additives should be used according to the standards; formula fertilization by soil testing should be popularized, as well as the technologies of diseases and pests control to improve the utilization rate of chemical fertilizers and pesticides. For instance,

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Pan'an County has installed 416 insect-killing lamps and more than 2200 sexual traps in Modern Agriculture Zone in Yushan Tableland, and has extended botanical pesticide. The physical biological control area reaches 890 hectares, and more than two times of fertilizer application is reduced each year, saving 750 yuan per hectare. In the "disease control by fertilizer reduction" pattern of Lianshu Sugarcane Cooperative in Wenling City, planting area of sugarcane is 246.667 hectares; the formula fertilization by soil testing is 212.533 hectares in the year 2009; fertilizer consumption per hectare is 28.65 kilograms less than the average level. Average increases of plant average, stem perimeter, yield and output value are 5.2 centimeters, 0.2 centimeter, 412 kilograms, and 233 yuan, respectively. Thus, it can be concluded that the pollutants emission is reduced while the output is increased.

1.1.2 Clean production. A clean production mechanism should be established. Drip irrigation and spray irrigation are widely implemented, as well as the new agricultural machineries with low consumption and high efficiency. The livestock clean breeding technologies and facilities, such as separating rain water from sewage and separating the wet from the dry, are also implemented in order to reduce the consumption of agricultural resources. In the year 2009, Jindong District in Jinhua City installs the Israel drip irrigation equipment, realizes the integration of fertilizer and water, and allocates the type and quantity of fertilizers and the water quantity according to the demands. Compared with the flood irrigation, drip irrigation saves more than 60% water, 2 730 tons of water per capita, more than 30% fertilizer, and 2 700 yuan per hectare. Implementing the pigs of improved variety, average daily gain in Zhaohui Animal Husbandry Co., Ltd. in Zhuji City has improved from 650 grams to 790 grams; and the material ratio has reduced from 3.1:1 to 2.7:1. At the same time, this method optimizes feed formulation, adopts the green feedstuff, adds enzyme preparation and few organic trace minerals, and reduces the discharge and smell of pig manure. After the modernization restructuring of swine pen, excretion of pig has reduced from 8.5 kilograms per day to 5 kilograms per day.

1.2 Ecological chain connection and conversion pattern

This pattern realizes the efficient use of resources through the effective connection and conversion of different industries, so as to achieve the minimum ecological pollution. It has the characteristics of polypolarity, multiformity, interactivity and symbiosis.

1.2.1 Combination of farming and grazing. Combination of farming and grazing is conducted in order to carry out land transfer around the farm to plant pasture and corn and to provide fodder grass for animal husbandry. After separating the dry from the wet in dairy manure, polluted water is put into methane tank. The fermented cow dung is used as organic fertilizer in the corn and forage planting. Biogas slurry is irrigated in the forage land through storage pool. Thus, the resource recycling between crop cultivation and aquaculture is realized. Every one thousand tons of corn and pasture used as dairy food can save 50 thousand yuan; each hectare can digest 75 – 90 tons of dairy manure; and every one ton dairy manure can save the at least 58 yuan cost of fertilizer.

1.2.2 New cropping pattern. Maximum resource utilization and minimum ecological pollution can be achieved among different industries and crops through new cropping pattern. Pan'an County is rich in garden and woodland resources, having 13.33 thousand hectares of tea garden, mulberry field, fruit garden, bamboo plantation and woodland hills. In the modern agricultural park, a total of 9 bases are established to stock 200 thousand chicken, which realizes the virtuous circle. Yuhang introduces the rice-duck farming pattern in the year 2000, and implements the (rotation) combination pattern of planting and breeding according to local conditions. At present, the application area has exceeded 3 330 thousand hectares; there are more than 1 million poultry; and the average income increase per hectare is more than 3 750 yuan.

1.3 Recycling pattern of agricultural wastes Ecological circular agriculture turns agricultural wastes into useful materials through processing, in order to improve the resource utilization rate, to change the situation of the serious waste of agricultural resources, and to improve the quality and benefit of agricultural production.

1.3.1 Comprehensive utilization of wastes. The planting of the traditional rice and the development of edible mushroom industry have produced a large number of straws, mushroom logs, and other wastes. Pinghu City has implemented the circular pattern of "rice – mushroom – asparagus (watermelon)", uses the paddy straws to plant mushroom, and takes the wastes during mushroom production as the organic fertilizer and bulking agent, so as to improve soil fertility to plant asparagus, to turn the wastes into organic fertilizer, improve the soil which plants watermelon, and to enhance the quality of watermelon[5]. In the year 2009, 35% straws in Pinghu City are used to plant mushroom, 20% mushroom wastes are used to plant asparagus and its the total area reaches more than 120 hectares; and 25% mushroom wastes are used to plant watermelon with the total area being more than 153.33 hectares. Jinyi Livestock Company in Longquan City takes the wastes of edible fungi and the fungus chaff of needle mushroom as the basic materials, and uses aerobic-anaerobic coupling fermentation technologies to produce protein feed. About 60% – 80% conventional roughage is replaced during fattening cattle, saving more than 30% of the feed cost.

1.3.2 Waste recycling taking biogas as the link. Through biogas project and the "811 Comphrehensive Control" in the large and medium poultry and animals plants, the green agricultural products are produced, and the reduction, recycle and safe treatment of wastes are carried out by returning the biogas and biogas residue into fields. Dayanhe Ranch feeds 5 000 pigs each year with the annual sewage discharge being 180 tons. Animal urine is fermented in the methane tank of the ranch. The methane obtained is applied in the 40 hectares of fruit and vegetable fields of Zhaichun Agricultural Development Company, which can enhances the soil fertility, improves the crop quality, and reduces the application of fertilizer. And the rest

methane obtained is used for the 26.667 hectares aquaculture base of Shanghushui Specialized Cooperative, which increases the organic content in fish pond, reduces the usage of soybean meal, rapeseed cake and other feedstuffs by 67 tons, and saves the costs by 230 thousand yuan.

1.4 Quality improvement pattern of agricultural products Quality of agricultural products directly affects the life quality, health level, development foundation and even the life security of human. The aim of developing ecological circular agriculture is to offer safe food for the people. Thus, multi-stage recycling is conducted from the input end and output end of production to realize the source prevention and whole process control. Zhejiang Liantain Ecological Agriculture Co., Ltd. uses pig manure to feed earthworms, earthworms to feed the soft-shelled turtles, the excretion of soft-shelled turtles to feed the bighead carps, and the excretion of bighead carps to feed spiral shells. Then, the small spiral shells can clean the organic matter in pond sludge and be used as the feedstuffs of soft-shelled turtles. Thus, an ecological circular pattern of "pig-earthworm-soft-shelled turtle-bighead carp-spiral shell" is established, which achieves the harmless disposal of animal manure. Besides, thought this multi-stage recycling pattern, pig farm of this company has win the certification of Pollution-free Livestock Base; the soft-shelled turtle has also win the certification of organic products. The company passes through the circular economy pilot projects at national level, and becomes the first company passing the pilot project in China.

1.5 The pattern of ecological circular agricultural park According to the concept of circular economy and the principles of industrial ecology, ecological circular agricultural park connects the producers (enterprises) in industry, agriculture, animal husbandry to form a mutualism network of "producer – consumer-decomposer" based on modern science and technology by relying on the industrialization of agriculture and taking scale management as the condition. Through resource sharing and products exchange, matter and energy are gradually transferred among different industries, which has greatly improved the use efficiency of resources, and has reduced the emission of the whole system[6].

Relying on the abundant land and tidal flat resource in the east, Ninghai vigorously develops the ecological circular agricultural park with 6 670 hectares in the east coast. The demonstration park aims to establish an ecological integrated production mode, actively promotes the organic coupling of industries, and forms a total of 7 circular development patterns, such as biogas projects in small and medium livestock farms, resource utilization of animal manure, mutualism of biological species, multi-level use of substances, facility agriculture combining the ecological agriculture, crop straw use, and reduction of agricultural resources. Three-dimensional ecological breeding patterns are taken as the typical models, such as "agricultural wastes – cow cultivation – organic fertilizer processing – crops", "livestock raising – manure – organic complex fertilizer – fruits and vegetables" and "fish and shrimp – shell and water plant". More than 60% of the agriculture products within the region have passed the high-quality processing and transformation; more than 60% agricultural products are exported; and more than 90% agricultural wastes are reused.

2 Policy suggestions to promote the ecological circular agriculture

At present, ecological circular agriculture in Zhejiang Province is at the exploratory stage, which is also basically the initial development stage. Therefore, to promote the development of ecological circular agriculture, Zhejiang Province should implement a series of effective incentive policies.

2.1 Improving the macroeconomic control mechanism led by the government Developing the circular agriculture is a kind of system engineering. As the subject of liability, government should vigorously promote the innovation of system, and improve the policy and legal system favorable for the development of ecological circular agriculture. Combining with the local conditions, government should make relevant polices and measures for the development of ecological circular agriculture, establish compensation, incentive and restraint mechanisms, actively explore the market operation mechanism of the investment in ecological circular agriculture, fully make use of the social forces to develop ecological circular agriculture, guide and encourage industry and commerce funds, foreign investment and social funds to participate in it, and establish a diversified investment mechanism based on government guidance and market operation.

2.2 Establishing the technological innovation system to promote the development of ecological circular agriculture According to the development requirements and technical characteristics of ecological circular agriculture, reduction technology, recycling technology, resource technology, environmental protection technology and systematic technology should be vigorously developed based on clean production, product safety supply and waste utilization. Enterprises should reinforce the innovation, develop agricultural high-tech industry, use high and new technology and advanced technology to upgrade the traditional agriculture, improve agricultural technology content, carry out integration research in the aspects of the technology linkages of agricultural clean production, the multi-stage transformation of green production technologies and agricultural resources, the technology standards of circular agriculture and so on. At the same time, integration research should be carried out in order to establish the relatively perfect technology innovation system and the technology demonstration and extension system promoting the development of circular agriculture.

2.3 Creating an atmosphere of developing circular agriculture Adhering to the subject of "developing circular economy; establishing economization-based society", advanced models and technologies of ecological circular agriculture should be extended. Government should pay attention to the guidance of advanced models, cultivate typical models of different types, and summarizes the typical experiences. Various media should be used to propagate the new measures, experiences and typical

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industry should be adjusted from the perspective of low-carbon economy and the marine service industry should be greatly developed, for instance, offshore tourism industry, marine cultural industry, marine creative industry (including software centre), modern marine logistics, modern marine telecommunications and marine related finance and insurance. The modern marine service industry should be guided according to ecological and low-carbon standard. For example, combining offshore tourism, island sightseeing, natural environment with the production of agriculture, forestry and fishery, fishing village culture and life to provide sightseeing and leisure environment for tourists, as well as enhance people' experiences on sea, islands, fishing village. It owns the education, economy, tourism, medicine, culture and environmental protection functions. The construction of offshore tourism industry can reference the demands of ecology, and it can change the products in the area into harmless, safe and nutritional food. Offshore tourism leisure industry is characterized by the diversity of marine creature and the elegancy of marine ecological environment, so it is an important model for developing low-carbon marine economy.

2.5 Directing the enterprises to seize the opportunities and accelerating the development of low-carbon economy Enterprises take the leading role in developing low-carbon economy. For one thing, the enterprise should take social responsibility; fulfill the obligation of reducing emission; enhance the efficiency of energy use in production, transportation and selling; reduce the emission of greenhouse gases. For another thing, the enterprises have many opportunities in developing low-carbon economy. in the future developmental process of coastal cities, the government should lead the enterprises to know the changes of the domestic and international policies on emission reduction; to make use of polices provided by Chinese government and international organizations on discharge fee, trading of emission right, emission trade, clean development mechanism(CDM) and the opportunities supplied by joint implementation mechanism (such as advance technology and capital support); so as to improve the efficiency of energy use and dampen the emission of carbon. The international emission reduction market also provide many opportunities to enterprises, for example, since 2010, the United Nations CDM Executive Board has had new change to CDM market. The gas emission reduction projects of big industry and chemical industry have faced more and more severe supervision. The former Chinese projects, which use wind power, small hydropower and have low industrial efficiency, have faced more and more severe supervision[6]. It can be seen that three are many opportunities in international and domestic emission reduction market. Thus, the projects including the construction of offshore forests, forests in deserted island and forests established by cooperating with oversea organizations, and some other projects that are conducive to improving the quality of environment and enhancing the capability of oceans in absorbing carbon should be reevaluated and known. In terms of fund collection of enterprises, the banks will treat the low-carbon enterprises and high-carbon enterprises discriminately. The low-carbon enterprises are easy to get the support from the banks, but the credit volume of high carbon enterprises will be limited. The policies are of great significance for the enterprises to grasp the opportunity to develop low-carbon economy.

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cases of circular agriculture by many forms. Through communication and education, economy consciousness of the carders and farmers within agriculture system should be strengthened, in order to improve the consciousness and initiative of developing circular agriculture, and to create a healthy social atmosphere of developing circular agriculture.

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