Emerging Patterns in Sustainable Agricultural Advancement Across Developed Nations

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Abstract

Against the backdrop of emerging environmental issues, sustainable agriculture has become a pivotal trend in global agricultural development. In recent years, countries worldwide have made extensive attempts to advance sustainable agriculture, with organic agriculture, energy agriculture, and agricultural informatization emerging as prominent new directions. This paper conducts a concise analysis of the trends in sustainable agricultural development in developed countries and summarizes their implications for China's sustainable agricultural development.

Keywords: sustainable agriculture, organic agriculture, energy agriculture, informatization

1. Introduction

As the foundation of the national economy, agricultural development is directly linked to national economy and people's livelihood. However, the emergence of issues such as population, environment, energy, and food security has restricted agricultural development to a certain extent. Consequently, sustainable agriculture has emerged and become a focus of agricultural development in many developed agricultural countries. To promote sustainable agricultural development, leveraging modern information and communication technologies, biotechnology, and other scientific advancements, many developed countries have actively explored new directions. Organic agriculture, energy agriculture, and agricultural informatization have thus become new trends in global agricultural development.

2. Organic Agriculture

Affected by the economic crisis, the global economic growth rate has slowed down, but organic agriculture has maintained continuous growth. In recent years, due to the extensive use of chemical agents such as pesticides and chemical fertilizers in traditional agriculture, as well as over-cultivation, soil erosion worldwide has become increasingly severe. Therefore, organic agriculture, which advocates controlling the use of chemical agents, applying natural organic fertilizers, and practicing crop rotation to protect land resources, has developed rapidly. According to statistics from the Organic Trade Association (OTA), organic agriculture has been growing at an average annual rate of approximately 9%.

2.1. Overview of Organic Agriculture Development in the United States

The United States is the world's largest organic agriculture market and still has great development potential. In 2011, the area of organic agricultural land in the United States was 4.9421 million mu (2 million hectares). The number of certified organic farms and ranches in the United States reached 17,281, an increase of 240% compared with 2002. The annual sales of organic agricultural products amounted to 29.22 billion U.S. dollars, an increase of 9.4% compared with 16.7 billion U.S. dollars in 2010, accounting for 4.2% of the total U.S. food sales in 2011. In the same year, a survey conducted by the Organic Trade Association (OTA) on "American Families' Attitudes and Perceptions towards Organic Food" showed that 78% of American families purchased organic food, and 30% of them had started purchasing organic food recently.

2.2. Overview of Organic Agriculture Development in Canada

In recent years, Canada's organic agriculture has developed rapidly, becoming the world's fifth-largest organic agriculture market, effectively increasing the income of farmers engaged in it and emerging as the fastest-growing industry in the agricultural sector. Statistics show that from 2001 to 2011, the total number of farms in Canada decreased by 17%, while the number of organic farms increased by 66.5% to 3,713, and the income of organic farms was generally higher than that of ordinary farms. Data from Canada's 2011 agricultural census indicated that the annual income of most organic farms fell within the

ranges of "$5,000–$99,000" and "$100,000–$249,999", whereas the annual income of ordinary farms engaged in other agricultural production mostly fell within the ranges of "less than $10,000" and "$10,000–$24,999".

Meanwhile, the market demand for organic agricultural products in Canada has been growing. From 2006 to 2010, the demand for organic agricultural products in Canada increased from 1 billion Canadian dollars to 2.6 billion Canadian dollars, a growth of 160%. In 2012, the total market value of Canadian organic agricultural products was 2.958 billion Canadian dollars, accounting for 1.7% of the country's total agricultural product sales, and 58% of Canadian consumers (with the ratio reaching 66% in British Columbia, Canada) purchased organic agricultural products weekly.

2.3. Overview of Organic Agriculture Development in Australia

In 2011, Australia's organic agricultural land reached 12 million hectares, making it the country with the largest organic agricultural land area in the world. Australia's organic agricultural production is dominated by organic animal husbandry: in 2012, the number of Australian farms certified as organic reached 3,069, of which approximately 75% were engaged in animal husbandry production. The sales of Australian organic agricultural products take various forms: through large supermarket chains, specialized organic product retailers, direct farm sales by farmers, farmers' market sales, and sales through cooperatives. In recent years, the decline in the proportion of direct farm sales by farmers and the increase in the proportion of organic agricultural products sold through large supermarket chains (reaching 75% in 2012) mark the "mainstreaming" of Australia's organic agriculture.

The "mainstreaming" of Australia's organic agriculture is a result of increasing market demand. A survey conducted in May 2012 showed that 65% of consumers had purchased organic agricultural products, compared with only 40% in 2008, and more than 1 million Australian consumers purchased organic agricultural products regularly. The main reasons Australian consumers choose organic products are that they are "chemical-free", "additive-free", and "more nutritious".

2.4. Overview of Organic Agriculture Development in Japan

Driven by the high prices and profits of organic agricultural products, as well as government support such as financial subsidies and tax reductions, the scale of Japan's organic agriculture has been expanding. Additionally, with consumers' growing emphasis on food quality and safety, the market demand for organic agricultural products has continued to increase, indicating great development potential. In 2009, Japan's output of organic agricultural products was 58,000 tons, accounting for 2% of the country's total agricultural output. In terms of production structure, organic rice, vegetables, and fruits dominate, accounting for 86.2% of the total output of organic agricultural products. In 2010, the number of farmers certified as organic was approximately 200,000, doubling compared with 2006. Studies have found that the average production cost of organic farmers is about 111.11% of that of non-organic farmers, but due to price differences, their profits are about 1.7 times that of non-organic farmers.

Japan attaches great importance to research on biotechnology related to organic agriculture, emphasizing cooperation between the government, enterprises, and research institutions to provide technical support for its rapid development. Its research mainly focuses on two aspects: research on crops' frost resistance, disease resistance, and pest resistance (using biological methods to improve crop characteristics, optimize growth processes, and increase yields); and research on production and environmental regulation (improving soil properties through natural substances, regulating crop growth environments, and enhancing production efficiency).

3. Energy Agriculture

Traditional fossil energy is scarce and non-renewable, with high carbon emissions, while the development of other new energy sources is difficult and inefficient. In contrast, bio-renewable energy has the characteristics of environmental friendliness, safety, high efficiency, wide application, and renewability, thus developing rapidly in the past decade, giving rise to the emerging industry of energy agriculture. In a narrow sense, energy agriculture refers to the cultivation of biofuel crops. The Food and Agriculture Organization (FAO) points out that in the past decade, the cultivation of biofuels has developed rapidly, stimulating the production of food crops, providing numerous opportunities for agricultural development, and offering new paths to increase farmers' income. Statistics show that biofuels have become the largest emerging source of demand for agricultural products, accounting for approximately 7% of global coarse grain consumption and 9% of global rapeseed oil consumption.

3.1. Overview of Energy Agriculture Development in the United States

The United States, with advantages such as advanced biotechnology, large arable land area, and high corn output, began researching and developing fuel ethanol in the 1970s. Currently, the production technology of fuel ethanol using corn as raw material has basically matured, making fuel ethanol a huge economic engine for American agriculture. In 2011, corn consumption for fuel ethanol production reached 130 million tons, accounting for 40% of the U.S. total corn output that year and 15% of global corn output. According to statistics from the Renewable Fuels Association (RFA), in 2013, the U.S. fuel ethanol industry directly created 86,504 jobs, with 45% of employees earning more than $75,000 annually, increasing the income of related agricultural families by $30.7 billion. In addition to fuel ethanol, biodiesel is also a key biofuel developed in the United States. In 2013, U.S. fuel ethanol production was 13.852 billion gallons, and biodiesel production was 1.359 billion gallons, a year-on-year increase of 37.13%.

The development of energy agriculture in the United States also benefits from government policy support. Based on the Energy Policy Act of 2005, the United States formulated the "National Renewable Fuel Standard (RFS1)" program, jointly designed and implemented by the U.S. Environmental Protection Agency (EPA), the Department of Agriculture (USDA), and the Department of Energy (USDE). It also mandates the addition of biofuels to transportation fuels through legal means, specifically requiring 2% biodiesel in diesel and 5% fuel ethanol in gasoline. On October 31, 2010, the U.S. Environmental Protection Agency announced its approval to raise the upper limit of fuel ethanol content in U.S. gasoline from the current 10% to 15%.

3.2. Overview of Energy Agriculture Development in France

Faced with high international oil prices, France has been developing energy agriculture (mainly referring to the biofuel industry based on cultivating biofuel crops) since 2003, leveraging its agricultural foundation to stabilize energy supply and consolidate energy security. The government planned to make biofuels account for more than 10% of the fuel market share by 2015. This not only helps France reduce its dependence on oil to a certain extent but also creates new development opportunities for French agriculture.

The rapid growth of French biofuels in transportation fuels has stimulated the development of energy agriculture. Currently, Europe's largest biofuel company is France's Diester Industrie, with an annual biodiesel output of 2 million tons. In 2010, the blended biofuel SP95-E10 (a biofuel composed of 90% unleaded gasoline No. 95 and 10% fuel ethanol) accounted for 13% of France's automotive fuel market share, doubling from 6.5% in 2009. Currently, 70% of cars on French roads (about 10 million vehicles) are compatible with this biofuel, and the number of gas stations supplying this fuel in France reaches 2,412, forming a strong supply network that provides good support for the application and popularization of biofuels.

3.3. Overview of Energy Agriculture Development in Canada

The development of Canada's energy agriculture industry mainly stems from government policy support and the resulting substantial market demand. Canada's National Renewable Energy Act stipulates a 17% reduction in carbon emissions by 2020 (compared with 2005 levels) and mandates that gasoline must contain 5% renewable fuels and diesel must contain 2% renewable fuels. This regulation has led to a surge in demand for biofuels, and Canada's biofuel industry has entered a stage of rapid development since 2005 (from 2005 to 2010, the annual average growth rate of fuel ethanol production capacity was 150%, and that of biodiesel production capacity was 140%). In 2007, the Canadian government launched the ecoENERGY for Biofuels Initiative, deciding to invest 1.5 billion Canadian dollars over nine years to fund producers of gasoline and diesel alternatives (such as fuel ethanol and biodiesel). To help farmers benefit from the development of energy agriculture, the Canadian government also introduced the ecoAGRICULTURE Biofuels Capital Initiative, investing 200 million Canadian dollars to provide financial support for farmers to build and expand biofuel production, significantly increasing farmers' production enthusiasm.

The development of the biofuel industry has also significantly driven rural economic development. Most Canadian biofuel production plants are located in rural areas; their construction can drive the development of equipment production and construction industries, and their daily operations can boost employment in surrounding areas and promote regional economic development. According to a survey by the Canadian Renewable Fuels Association, in 2010, there were 27 fuel ethanol and biodiesel plants under construction or in operation in Canada, creating a total of 15,215 jobs.

In addition, Canada is committed to developing commercialization technologies for producing ethanol from non-food biomass, i.e., using fibrous materials. It is currently a world leader in developing low-cost technologies for converting fibrous materials into ethanol. This type of fuel ethanol uses agricultural and forestry waste as well as fast-growing wood (such as wheat straw, corn stover, wood chips, switchgrass, and poplar) as raw materials, with huge market potential in Canada, which is rich in agricultural and forest resources.

3.4. Overview of Energy Agriculture Development in Australia

Australia's energy agriculture development is dominated by biodiesel, with strong government support, especially in transportation fuels. In September 2006, the Australian government issued fuel standards for biodiesel, specifying physical and chemical parameters and official testing methods for biodiesel. All urban light rail and buses in Adelaide, the capital of South Australia, use B5 blended fuel (containing 5% biodiesel), and the South Australian government is working to upgrade to B20 (containing 20% biodiesel) or blended fuels with higher biodiesel content.

According to the *Sydney Morning Herald*, since 2012, Qantas Airways in Australia has used blended fuel containing 50% biofuel on domestic flights. After use, fuel costs were reduced to 2.82 billion Australian dollars (with 1 Australian dollar approximately equal to 6.4 yuan at that time), about half of the previous cost, and carbon emissions were reduced by nearly 60% compared with traditional fuels.

4. Agricultural Informatization

With the continuous development of computer science, information technology has gradually been applied to various aspects of social production and life. Agricultural informatization applies information technology to agricultural production, sales, and other links. Through the analysis of historical and real-time agricultural data, scientific decisions are made to promote the full utilization of agricultural resources, thereby achieving sustainable agricultural development.

4.1. Overview of Agricultural Informatization Development in the United States

The U.S. government and enterprises have invested substantial funds in supporting and developing agricultural informatization, promoting new developments in agriculture. The U.S. government attaches great importance to agricultural informatization, allocating $1.5 billion annually to build agricultural informatization service networks to support government agricultural policy formulation and decision-making by agricultural enterprises and farmers. Currently, the United States has built the world's most extensive agricultural informatization service system, covering 46 states in the contiguous United States, 6 provinces in Canada, and 7 other countries, benefiting farmers in the United States and related countries. The U.S. Department of Agriculture (USDA) and its subordinate departments have also built a series of agricultural informatization service systems, such as geographic information system (GIS) tools like VegScape and CropScape, agricultural information platforms or databases like AGNC and PSD Online, and early warning mechanisms for agricultural product market information analysis (see Figure 1 for specific functions and system construction).

Meanwhile, some large U.S. agricultural enterprises are committed to agricultural informatization construction. Typical enterprise informatization service systems include FarmSight, Myjohndeere.com, and the mobile application FarmSight Mobile Farm Manager launched by John Deere, an American agricultural and construction machinery company, as well as the Cropio system launched by New Science Technologies. These systems integrate various agricultural data and feature real-time expert guidance, aiming to help farmers improve production efficiency, increase crop yields, make correct production decisions, and thereby increase income levels.

Figure 1. The Construction of Agricultural Information Service System of the U.S. Government

Type	Components	Functions
Core Data Resources	• Crop production & market statistics • Livestock/dairy/poultry inventories • Farm labor & wage metrics • Land transaction records • Agricultural research outcomes • Technical guidance repositories	Foundational data provision and standardization
Technology Infrastructure	• 3S Technologies (RS/GIS/GPS) • Economic modeling systems • University research networks • Cloud computing platforms • National agricultural databases	Data acquisition, processing, and analytical operations
Service Modules	• Agricultural Information Service Platform • Market Analysis & Early Warning System • Farm Decision Support Toolkit • Policy Development Interface	• Optimizing crop productivity • Mitigating natural disaster impacts • Supporting agricultural operational decisions • Informing governmental policy formulation • Facilitating academic research collaboration • Enabling agribusiness intelligence

4.2. Overview of Agricultural Informatization Development in Japan

The development of agricultural informatization in Japan has triggered significant changes in agricultural production and sales methods, promoting the optimization and upgrading of the agricultural industrial structure. Under government leadership, Japan has established a vast informatization service network in collaboration with national and local research institutions, covering various information such as crop cultivation techniques and pest control, and enabling real-time communication between farmers or agricultural cooperatives and research institutions. Based on this informatization service network, systems for statistics and forecasting of production quantities and price trends of various agricultural products nationwide, as well as market sales information service systems, have been established.

In addition, the Japanese government attaches great importance to the construction of infrastructure for agricultural informatization. To popularize computers in rural areas, the Japanese government provides subsidies to farmers purchasing computers, organizes training for farmers on computer usage, and develops system interfaces suitable for the elderly. The Ministry of Agriculture, Forestry and Fisheries of Japan has also formulated the "Informatization Strategy in the Field of Agriculture, Forestry, and Fisheries in the 21st Century" to build and improve rural information and communication infrastructure.

4.3. Overview of Agricultural Informatization Development in France

In the past decade, agricultural informatization in France has entered a stage of rapid development, with an increasing contribution rate to the agricultural economy. France has a comprehensive agricultural informatization service system, forming a multi-stakeholder information service structure led by the national Ministry of Agriculture, with cooperation from various industry associations, farmers' cooperatives, and private enterprises. The national Ministry of Agriculture and its subordinate agricultural departments at the regional and provincial levels collect data and information through diverse methods: based on general surveys, mainly using sampling surveys, supplemented by various special surveys to collect grassroots data for aggregation and analysis. To ensure the authenticity and reliability

of data, the Ministry of Agriculture and its subordinate departments strictly select and train information collectors, and French laws stipulate that "all producers and operators of social products are obligated to truthfully report their production and operation status, and violators shall be punished for tax evasion".

As an important part of French agriculture, animal husbandry has gradually established an informatization production management system. Taking dairy farming as an example: dairy farms establish databases for their cows, recording detailed data such as each cow's physiological indicators, health status, and milk production. Through data analysis, they accurately calculate the optimal milking frequency and quantity for each cow to ensure maximum milk output while maintaining cow health. At the same time, they can determine production volumes based on real-time and historical market information released by the state and industry associations to prevent overproduction and avoid significant price fluctuations.

5. Implications for China

Based on the research on new trends in sustainable agricultural development in developed countries, the following insights can be drawn for China:

5.1. Strengthening Government Policy Support

As analyzed earlier, the development of organic agriculture, energy agriculture, and agricultural informatization in developed countries has received strong government support, and such support has been elevated to the level of national will in the form of laws. A root cause of many issues in China is the lag in legislative work. Many new directions in agricultural development lack strong policy and legal support, leading to a lack of legal basis, ineffective implementation, and limited results. Therefore, China should learn from developed countries to strengthen legislative work and enhance government support.

5.2. Improving the Scientific and Technological Research and Development System

Developed countries attach great importance to investment in basic research and promotion of agricultural technologies, forming a tripartite scientific and technological research and development structure involving the government, enterprises, universities, and research institutions, which provides strong technical support for agricultural development. In China, universities and research institutions currently engage in basic scientific research, relying mainly on government funding with little cooperation with enterprises. This results in slow marketization of scientific and technological achievements and low enthusiasm among researchers. Therefore, China should establish a sound system for scientific and technological research, development, and promotion to accelerate the transformation of scientific and technological achievements.

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