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**MODELS AND STRATEGIES FOR THE DEVELOPMENT OF  
CIRCULAR AGRICULTURE IN CHINA**

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**Abstract**

*This paper proposes a systematic definition of circular agriculture and describes its basic features and implications, with reference to the circular economy models of the Dupont Corporation, the Kalundborg Industrial Symbiosis of Denmark, the DSD recycling system of Germany and the recycling society of Ayacho, Japan. It further categorizes prevailing models for the development of circular agriculture in China and analyses typical characteristics. The paper concludes with policy proposals and suggested strategies for the development of a circular economy in China's agricultural sector.*

**Keywords:** circular agriculture, circular model, development approaches, strategic proposals

**Introduction**

The development of a circular economy is a declared national strategy. The objectives to “Energetically develop a circular economy and progressively put in place structures for resource-efficient production and consumption” were stated at a Central Economic Work Conference on 3 December, 2004. In addition, the deliberations of the Fifth Plenum of the 16<sup>th</sup> CPC Central Committee held in Beijing on 11 October, 2005 called for: “accelerating progress towards a resource-efficient, environmentally- friendly society; energetically developing a circular economy; bolstering efforts in respect of environmental protection; ensuring practical protection of natural ecosystems; striving to overcome environmental problems affecting economic and social development, especially those jeopardizing public health; putting in place models for improving resource efficiency and encouraging healthy consumption throughout society.”

Circular agriculture involves applying the principles of the circular economy to agricultural production. The production chains of agricultural production and product life cycles are extended so as to reduce material and resource inputs as well as waste outputs, and achieve a circle that is both ecologically and economically benign.

**Part 1. Features and Implications of Circular Agriculture**

Strategies aiming to ensure sustainable development have become a worldwide trend since the 1990s, on the basis of efforts aiming to achieve maximal resource utilization while reducing the production of

wastes and pollutants to a minimum. Various concepts such as clean production, comprehensive resource utilization, ecological design and sustainable consumption have been drawn together and blended to formulate systematic strategies for a circular economy.

The 'circular economy' is a model for economic development that "promotes coordination and harmony of man and nature". It requires utilization to the greatest possible degree of materials and energy that enter the system so as to boost resource utilization rates and achieve a parallel reduction in pollutants produced. The result is greater quality and efficiency of economic activity. The theory of the circular economy has opened up new perspectives for agricultural development in China.

### ***1. Concepts of Circular Agriculture***

Circular agriculture is an entirely new concept and set of strategies, an improved approach to agricultural economy that addresses the coordinated development of populations, resources and the environment. At its core are the principles of sustainable development, circular economy and extended production chains. Many factors are involved, which can be enumerated as follows: technological innovations and organizational reforms; optimization of the internal and production structures of agri-ecological systems; extension of production chains; multilevel, circular utilization of energy; maximal utilization of biomass energy resources; utilization of every material link in the production process; promotion of clean production and conservation-minded consumption; stringent control of harmful inputs and waste production; maximum reduction of pollution and ecosystem destruction. At the same time, efforts are made to increase the value of each stage of production and to improve the quality of the human environment so that production and producers alike take their place in a benign agri-ecological circle conducive to the harmonious development of the agricultural industry and rural communities alike.

### ***2. Characteristics of Circular Agriculture***

The principal characteristics of circular agriculture are:

1. In keeping with the principles of resource conservation, it emphasizes improving the production environment and protecting farmland biodiversity as the foundation of stable, sustainable development.
2. It advocates an industrial approach to agriculture management, stressing clean production practices, technological improvements and the use of environmentally-friendly 'green' agro-chemicals so as to minimize environmental impact.
3. It applies technology to optimize the structural order of agricultural systems, organizing production according to the feedback model of: resources → product → waste → recycled resources, thus obtaining the maximum utility from resources committed.
4. It extends the eco-industrial chain of agriculture by encouraging the reutilization of wastes, elemental coupling, etc. in conjunction with related industries, thereby fostering production networks and collaborative development.
5. By encouraging 'clean' and conservation-minded lifestyles in rural communities, it promotes a beneficial modern culture.

In summary, the principal characteristics of circular agriculture are in the extension of production chains and resource conservation.

The production chain of circular agriculture extends from crop cultivation, the forestry, fishing and animal husbandry industries and their associated processing, trade and service industries to the end consumers of the various products. It also includes the exchange and reutilization of wastes and by-products and elemental coupling and linkages with other industries to shape a collaborative, inter-connected and inter-reliant network for agricultural production on an industrialized model. The various industries are further connected through the exchange and interlinkage of intermediate and waste products, thus completing the make-up of what can be a closed network. In it, resources are allocated in an optimal manner, wastes are put to efficient use and environmental impacts are kept to a minimum.

### **3. *Superseding Conventional Agricultural Practices***

As a low-input, high-recycling, high-efficiency, high-technology and industrialized set of practices, circular agriculture is distinct from conventional or traditional agriculture and represents a revolution in the sector. [5]

It surpasses conventional agricultural practice in 4 major areas:

1. In its theoretical orientation, circular agriculture borrows from modern industrial practice, applying the concepts of clean production and circular economy to agricultural production and management. It advocates control over the entire production process and product life-cycle so as to forestall any occurrence of pollution or contamination. It also requires that producers abide by the “3 R’s” of the circular economy, in that its priorities are to Reduce, Reuse and Recycle, and minimize production of wastes.
2. With respect to production methodology, circular agriculture incorporates the essential practices of conventional agriculture, yet increases the efficiency and effectiveness of both inputs and output. It also advocates comprehensive application of high technology to the agricultural sector, and aims to gradually replace high material inputs with technological alternatives while maintaining high productivity.
3. With respect to industrial cooperation, and efforts to enhance the degree of industrialization of agriculture, circular agriculture aims to put in place eco-production systems throughout the agricultural sector and its related industries. The key point is to optimize internal production structures, extending and broadening production chains so as to achieve multilevel, circular utilization of resources at both the agri-ecological and regional levels, and ensure the continuance of benign ecological cycles.
4. With respect to production and eco-efficiency, circular agriculture advocates multilevel circular utilization of resources with moderation in external inputs. This leads to improved productivity, higher quality and reduced production costs. Economic and ecological efficiency are enhanced and agriculture can achieve sustainable development in the true sense of the term.

## **Part 2. Circular Economy Models from Abroad**

Four principal models for the circular economy are current on the international scene. They are represented here by the individual enterprise model of the Dupont Corporation, the industrial symbiosis model of the Kalundborg region in Denmark, Germany’s DSD recycling system and the recycling society active in Ayacho, Japan.

### **1. *Dupont's Corporate-Internal Circular Economy***

The Dupont Corporation began experimenting with the principles of the circular economy in the 1980s. By initiating circular approaches to the use of materials in all areas of its operations and extending its production chains, Dupont was able to reduce consumption of energy and materials while also restricting the production of wastes and release of harmful pollutants. The company also used recyclable resources wherever possible and sought to ensure greater durability in its products. With the help of some creative thinking, Dupont incorporated the “3 Rs” principle into its manufacturing processes, abandoning the use of certain harmful chemicals, reducing the quantities used of others, and developing new techniques for recycling the company’s own products. By 1994, Dupont had cut down its production of plastic wastes by 25%, and emissions of atmospheric pollutants by 70%. [15]

### **2. *Symbiosis at the Kalundborg Industrial Park***

The industrial community at Kalundborg in Denmark is built around a core of 4 major enterprises – a power station, an oil refinery, a pharmaceutical plant and a plasterboard factory. Interacting on a trading basis, these various entities use the wastes and byproducts of their neighbours as raw materials in their own production processes. This cuts down on processing costs and waste, and with its eminent economic efficiencies, results in a benign circle of economic development and environmental protection. The Park boasts a very talented management team that handles the coordination, organization, account settlement and oversight tasks for the 4 major plants and other participating enterprises in the area. The team also coordinates funding and technical support for new waste recycling projects, and by facilitating logistical, energy and information flows, achieves orderly and efficient production on the circular model.

### **3. *Germany's DSD Collection and Recycling System***

The *Duales System Deutschland* (DSD) is a non-profit organization tasked to manage the recycling of packaging waste. It was established by a group of 95 packaging producers, garbage recyclers and other businesses in 1995 and now counts some 16,000 members. These entities constitute a network that channels recyclable materials – identified by a green dot - to recycling plants for processing. The basic principle of the green-dot programme is that of producer responsibility – that the production of waste incurs a cost. Member enterprises thus pay fees that support the collection, cleaning, sorting and eventual recycling of discarded packaging materials.

### **4. *Organic Farming and Resource Recycling in Ayacho, Japan***

This project began on a small scale with the collection of drainage sludge, poultry droppings and organic industrial wastes as fermentation materials for the production of methane to be used to generate electricity. Solid remainders from this process were composted and dried for use as fertilizers, while liquids were re-processed or discarded, insofar as they did not represent an environmental threat. The result of the programme was to achieve a high degree of waste-to-resource recycling and remove potential threats from the environment. 16 years later, the programme has now developed into a largely organic circular agricultural industry that has wrought great improvements to the eco-environment in Ayacho Town, Miyazaki Prefecture, while enabling steady economic development, greatly improving farmers’ livelihoods and contributing to social order and tranquility. [8]

These models of circular economy from outside China all feature the “3 Rs” in that they emphasize reductions in resource use and waste production, and multiple reuse or recycling of waste materials. They also result in more economical resource use, cleaner production processes, eco-transformations of production chains, recycling of wastes and eco-friendly ‘green’ consumer practices in society at large. Indeed, the close interaction of agriculture with the natural environment is an indissoluble condition that

predisposes the agricultural economy to harmonious inclusion in the recycling processes of natural ecosystems, and this provides a model for the development of a circular agricultural economy.

### **Part 3. Categories and Characteristics of Circular Agriculture in China**

#### **1. *Models based on Integration of Eco-Agricultural Patterns***

The production process in this approach is penetrated by the basic idea of achieving concurrent benefits for the economy, the environment and society. It represents the bare essence of the eco-agricultural model. It stresses the overall ecological effects of agricultural development, and based on establishing circular mechanisms linking “resources to products to reuse to re-production”, achieves harmony between economic development and ecological equilibrium. It is characterized by low levels of resource consumption and pollution production, and maximized utilization of energy and materials. Through farmers’ associations or similar organizations, it brings scattered farmers under centralized management and broadens the scope of production, resulting in the integration of cultivation, animal husbandry and product processing in one production model.

Farmers’ associations in Linquan County of Anhui Province, for example, have developed what amounts to a classic model for circular agriculture in China. The production model developed by local farmer Wang Shouhong, which features linkage of forest products, grasses, livestock, fungi, biogas and fertilizers, complies with the principles of circular agriculture and results in greater economic and social benefits. It has proven particularly valuable in the handling of cattle manure, for which three downstream channels have been found, in the production of mushrooms, methane and foodstuffs respectively. His model has extended and broadened an originally simple eco-agricultural production chain to obtain greater economic efficiencies. [10]

#### **2. *Models Targeting the Multilevel Utilization of Agricultural Wastes***

In conventional models of agricultural economy, bio-based industry using agricultural wastes as a resource has not been integrated into the circulative loops of the overall production system. Given the degree of global interest in the exploitation of bio-energy resources and the growing maturity of bio-energy transformation technology, however, the industry merits close attention. Indeed, bio-energy resources are of particular interest for their potential in alleviating the global energy crisis. [11] The prime characteristic of this model is that it integrates bio-industry as an important subsystem of the overall agricultural industry. Wastes are sought for their resource potential particularly in the processing stages where waste water, gases and solid residues are channeled for further utilization. Throughout the whole materials circulation system, in fact, there is no such concept as ‘waste’, but only of ‘resources’.

The model developed in the Eastern Xihu district of Wuhan, for example, achieves standardized, large-scale production of raw materials by integrating “industry, locality and farmers” in a system that brings in orders of RMB60 million annually to local cattle farmers. At the same time, manures and liquid animal wastes are processed in a composting facility that uses modern fermentation and odour-reduction technology to produce high-quality organic fertilizers that bring in a further RMB10 million of income.

#### **3. *Production Park-Based Total Circular Agriculture***

The successful experiences of Ecological Industrial Parks in North America are the inspiration for this model that aims to achieve total circular production. Four subsystems – cultivation, animal husbandry, product processing and bio-based production – are incorporated into a closed system for circular production. The flow of materials operates in two major loops. One is external, and includes the processes of transformation from production to consumption; the other is internal, and involves the recycling and reutilization of waste resources. A set of symbiotic and interdependent relations is thus created that links

the material flows and value streams of the different production systems and achieves the greatest possible extension of production chains.

An example is the Ecological Industrial Park model developed in the Sujiatun district of Shenyang, which has an agro-tourism concept at its core. The external framework consists of the various systems governing grape cultivation, wine production, anti-oxidant bio-engineering, bio-fertilizers production and environmental protection, such that the respective functions of the grape, manufacturing and agro-tourism industries are combined in a single entity that manifests itself in a closed-loop eco-economic network.

There are two principal production chains. The first is the closed loop of grape cultivation, product processing and fertilization. Its particular feature is the bio-engineering reprocessing of agricultural wastes as organic fertilizers that are returned to the soil. The second is another loop that includes the eco-residential area, household-waste processing, pond-based aquaculture and return of fish manures to fields as fertilizer. The prime feature of this loop is that the clean resources and organic fertilizers produced can be reutilized in the commercial and agricultural sectors as well. [14]

#### **Part 4. Directions and Approaches for the Development of Circular Agriculture in China**

##### ***1. Directions for the Development of Circular Agriculture***

The overall progress of social and economic development is to be led according to scientific principles to promote a conservation-minded society and socialist development in rural communities. The various principles of harmlessness, low emissions, zero damage, high benefits, sustainability and environmental beautification apply to ensuring sustainability in both agricultural production and rural consumption, and to promoting coordinated development of the rural economy. Agriculture and rural industry, production and living conditions, rural infrastructure development and urbanization will be the object of comprehensive planning, with the promotion of conservation-oriented development, clean production processes, utilization of wastes as resources and clean consumption as starting points. Finally, further reforms in technological paradigms and methods of organization will favour the development of circular economic systems in rural communities.

With respect to resource utilization, conservation will be paramount, with first priority to be given to achieving increased efficiency of water and land usage, as well as of investments. To these ends, new concepts of cost-limitation must be applied to conventional practices, and every effort made to economize in the use of water, land, energy, fertilizers, chemicals and labour, as well as to increase the recycling of agricultural resources and bolster the capacity for sustainable development.

With respect to waste processing, the objective is to encourage reutilization of wastes as resources, so as to achieve total reutilization of bio-resources that accumulate during crop production, cut waste output in poultry and livestock raising and convert animal manure wastes for resource purposes. In particular, efforts are to be made to find alternative uses for the straw by-products of cultivation, moving beyond the familiar production of methane to investigate their potential in other bio-energy or microbial resource applications, while the most economical uses are to be found for manures. These various measures will promote circular utilization and resource-oriented development.

With respect to the production chains of the agricultural industry, initiatives include promoting clean production, utilizing the wastes of one link as resources in another, achieving increases in the value chain and expanding the scope of industrial approaches to agriculture. A major focus in this respect will be achieving internal extensions and interaction of various productive elements, and consolidating the concepts, directions and models in use to extend the domain of industrial-type management. Such extension is the wellspring for sustained growth in the added-value of the rural economy. It will strengthen

regional economies and contribute to increases in farmer income, and as such will be instrumental in the development of circular agriculture.

With respect to infrastructure development in rural areas, efforts are to focus on developing circular communities with access to methane and solar power as energy resources so as to reduce reliance on outside inputs. “Clean consumption” will be encouraged with local treatment of refuse, while, with a view to building new socialist communities, practical steps will be taken to operate infrastructure improvements in rural areas in order to improve the people’s living environment.

## **2. *Strategies for Development of Circular Agriculture***

In the aim of building a harmonious socialist society, developing a circular economy in the agricultural sector and achieving a new socialist order in rural areas, work is presently required in the areas described below. [2]

### **a. *Planning for the Development of Circular Agriculture***

With respect to provisions for agricultural development to be included in the 11<sup>th</sup> 5-Year Plan, plans should be drawn up for the encouragement of circular agriculture with particular focus on conservation, high-efficiency resource utilization, recycling of wastes, clean production as production chains are extended, and ‘clean’ infrastructure improvements in rural communities. Meanwhile, directions, objectives and usable models of relevance to the next 5 years should be proposed, including engineering measures, support for important areas of activity and necessary safeguards. Specific planning is required to address economies in water, land and fertilizer use, as well as in labour and costs in general, and the comprehensive utilization of agricultural resources. Similarly, major areas of focus should be identified, and development targets and policy measures drawn up.

### **b. *Structural Adjustments and Optimizing the Agricultural Economy***

Regional agricultural development should be directed in accordance with the principles of the circular economy. With reference to the particular available resources and structural features of the agricultural industry in each area of the country, rational adjustments can be made to regional patterns of agricultural activity so as to put in place region-wide systems for circular agriculture. Specializations of production can be promoted along regional lines, while the optimum-scale management schemes and industrial clusters required for effective circular agriculture should be put in place. Meanwhile, ‘raw material’ bases should be developed to support the extension of production chains and the industrial processing of wastes. Finally, infrastructure development in rural communities and smaller towns is required to ensure proper processing of refuse and lay the foundations for a pleasant living environment.

### **c. *Technical Integration Systems to Promote Circular Agriculture***

Agricultural development should be supported by the application of advanced skills and high technology to restructure and improve upon traditional agricultural practices, particularly through the development of “factory farming” and “manufacturing agriculture.” The technical component of agricultural products should be constantly increased and greater space found in the industry for technical integration and innovation so that due technological support is available to the agricultural economy.

Early efforts in this direction should emphasize: the technical linkages inherent in clean production; green production technologies and multilevel resource transformations; technical support to resource conservation through efficient utilization and waste recycling; formulating technical standards for circular agriculture; eco-urbanization technologies for developing rural communities; green consumption

technologies for rural inhabitants. In addition, research should be conducted to establish new systems to support technological innovation and promote technical models of relevance to circular agriculture.

*d. Pluralistic Investment Mechanisms and Model Programmes*

In keeping with the policy of building a new socialist countryside, and guided by the principles of the circular economy, new, pluralistic investment mechanisms led by government inputs should be established during the 11<sup>th</sup> 5-Year Plan. In this respect, a few model programmes should be established on a nationwide basis that address such important aspects of the circular agricultural economy as resource recycling, conversion of crop straws and animal wastes to resources through non-harmful processing, 'clean' infrastructure development in rural communities, development of bio-energy potential, circular utilization of microbiological resources, etc. In addition, new development models for circular agriculture and new methods of resource utilization adapted to the resources available in differing regions should be developed, so as to ingrain the principles of circular agriculture in the daily life of rural communities.

*e. Structural Innovation to Create a Favorable Policy Environment*

There are at present several areas in which vigorous intervention by the competent authorities to promote innovations would be beneficial to the development of circular agriculture. These include bringing adjustments to state policy and to the legal system. Specific measures that would be conducive to creating the favorable environment needed would include increasing financial support to the agricultural sector, implementing market-style reforms in rural communities, establishing organizations dedicated to the promotion of circular agriculture, and improving basic agricultural infrastructure and environmental management. At the same time, socialized service systems should be developed for rural inhabitants that align with national legislation concerning the circular economy, as there is some urgency to putting in place the legal safeguards and corresponding policy guarantees to support the development of circular agriculture.

The preliminary legislative work should begin as soon as possible, and favourable policies put in place to address tax relief, financial guarantees and subsidies. In addition, practical and effective measures are required to promote infrastructural development in the countryside. Further measures urgently required include the drafting of regulations to govern clean production in the agricultural sector, as well as standards in this respect and for environmental cleanliness in rural areas. In this way, the development of circular agriculture and a conservation-minded rural society can be brought within the ambit of legally-prescribed and standardized administrative management.

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