China’s Ecological Agriculture: Progress and Perspectives

LI Wenhua*1, LIU Moucheng and MIN Qingwen

Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China

Abstract: Agriculture is the basis of national economy. Through science and technology and the intensive utilization of land, great achievements have been made in agriculture. However, some agro-ecological and environmental problems are rising. Because of this, people have begun to reflect on agricultural developmental policy, patterns and technologies, and put forward new thoughts for agricultural development. In the late 20th century, China’s ecologists and agronomists co-sponsored the concept of ecological agriculture with Chinese characteristics. Its essence includes a series of concepts such as integration, coordination, circulation and regeneration within agroecosystems or within systems of agriculture production, processing and marketing. After nearly 30 years of practice and development, ecological agriculture in China has achieved remarkable outcomes. However, current eco-agriculture development is unsatisfactory due to the following two factors: (i) A lack of research and accounting across a variety of agro-ecosystem service functions; (ii) It is difficult to obtain remarkable economic benefits because of the lack of market-oriented guidance, scale management, specialized production and brand popularization for the traditional autarkic peasant economy. In order to further promote the development of ecological agriculture it is necessary to engage in serious reflection on ecological agriculture in China and arrive at new understandings about circular economy, multifunctional agriculture, high-quality agriculture, industrial development, integration of the traditional essence and modern technology, and finally, the sustainable development of rural areas.

Key words: ecological agriculture; circular agriculture; multifunctional agriculture; high-quality agriculture; agro-industrialization; agro-cultural heritage

Agriculture experienced the development process from the slash and burn, autarkic individual agriculture to modern agriculture, is the basis of the national economy. Through the progress of science and technology and the intensive utilization of land, the great achievements have been made in agriculture. However, some agro-ecological and environmental problems are rising (Li 2008). People have begun to reflect on agricultural development policies, patterns and technologies, and put forward new thoughts for agricultural development in succession, such as organic agriculture, biological agriculture, natural agriculture, integrated agriculture, cycling agriculture, ecological agriculture and sustainable agriculture (Cheng et al. 1997). The names and meaning of these terms vary, but all reflect the ecological thought and the strong need and desire to explore sustainable agriculture. There is growing awareness that the development of agriculture is not only the increase of the amount of food and agricultural products but also the improvement of product quality, insurance of food safety, exertion of ecosystem functions and maintenance and restoration of the ecological environment.

The long history of intensive cultivation customs combined with a vast expanse and extremely complex geography provides unusual social and technical conditions in the development of low input and highly intensive agriculture in China (Luo 2007). However, characteristics such as a large population, land scarcity, water resource shortages, environmental vulnerability and complicated natural conditions, large ecological deficits, and rural poverty mean that it is very difficult to nationally popularize the patterns adopted by developed countries. It is necessary to explore a modern agriculture development route with Chinese characteristics (Li 2004).
In the late 20th century China’s ecologists and agronomists co-sponsored the concept of ecological agriculture with Chinese characteristics: “The ecological agriculture is, deriving from systematic thoughts, according to the principles of ecology, economics, and ecological economics, with the application of modern scientific and technological achievements and modern management tools, as well as the effective experiences of traditional agriculture. It is the modern agricultural development model to obtain a higher economic profit, ecological and social benefits.” (Ma 1997; Ye 1998). Its essence includes a series of concepts such as integration, coordination, circulation, and regeneration.

After nearly 30 years of practice and development, ecological agriculture in China has achieved remarkable results including: (i) Establishment of a theoretical system and summary of successful models (Li et al. 1994; Li et al. 2005); (ii) Eco-agriculture demonstrations within the county-level pilots and achieved significant effects (Wang 2001; The National Ecological Agriculture Demonstration Construction Experts Committee 2001); and (iii) China’s eco-agriculture has been widely recognized and praised by the international community (Li 2001) and become one of the first selected units for agricultural cultural heritage (Min 2006).

Despite these achievements, eco-agriculture development remains unsatisfactory. This is mainly due to the following factors: (i) The concept and definition of ecological agriculture is vague; (ii) It is difficult to obtain remarkable economic benefits because of the lack of market-oriented guidance, scale management, specialized production and brand popularization for the traditional autarkic peasant economy; (iii) A lack of further research and accounting across a variety of agro-ecosystem service functions; (iv) A lack of corresponding matching techniques; (v) A lack of policy support and economic compensation; (vi) Weak in the scientific research support; and (vii) A lack of capacity-building.

The development of society presents new situations and problems, and scientific progress widens our new visual field and provides new means of resolving issues (Jia et al. 2005). In order to further promote the development of ecological agriculture, it is necessary to engage in serious reflection on ecological agriculture in China and obtain new understanding in the key areas we discuss below.

1 Develop cycling agriculture from a single sector to multi-industrial circulation

In China, ecological agriculture emphasizes “food chains” and “food webs” in the industrial ecology system through transverse coupling and resource sharing between different processes. It can achieve substance recycling and stratified using, and remove a number of endogenous and exogenous contaminants. Finally, it aims to transfer the negative effects of pollution to the positive benefits of resources (Li and Zhang 2005). In China, ecological agriculture mainly makes use of the organic link between the internal modules, and then achieves the purpose of material recycling. It also establishes the internal composite system in the agriculture system, in order to improve the relationship among original producers, consumers and disintegrators in the agriculture ecosystem (Luo et al. 2008).

With the improvement of the “market economy system” and a “scientific outlook on development”, ecological agriculture, which is narrowly limited to the field of agriculture, is difficult to adapt to social development. For sector limitations and incomplete industry chains it is hard to solve some agriculture problems in China such as resource shortages, pollution and rural labor shortages. It is also difficult to reach the level of a prosperous society. Modern ecological agriculture should gradually change the idea that the only product of agriculture is self-sufficiency and should in turn organically integrate with industry. The manufacture of agriculture product should become the core and connected to marketing, producing and circulating. Finally it should integrate producing and selling and form a whole industry network chain. Modern ecological agriculture should contain production, distribution, consumption and recycling; and follow a food web structure which mainly involves industrial planting, industrial cultivating and waste recycling in the field; it should make full use of resources, information, facilities and labor to form a virtuous “cyclic economy” framework. Finally it should achieve coordinated development of ecological, social and economic effects.

The key to achieve a healthy circulation of agriculture ecosystems is to conserve agriculture resources, further agriculture production and manufacture and recycle waste. Agriculture resource conservation means the rational exploitation of land, water and energy, and the rational application of fertilizers and pesticides. Further agriculture production and manufacturing should be coordinated with brand product and scale product to promote the upgrading of manufacturing processes (Zhang et al. 2004). Conditions for research that demonstrate further production and manufacture should be promoted. There are many ways to recycle waste such as using straw to produce bio-feed and using manure to produce bio-fertilizer. All of these are based on the concepts of food chains and trophic levels. According to silage ammonization, they mainly produce methane by agronomic and other ways, and then make full utilization of agriculture organic waste from crop straw, livestock manure, and the residues of agricultural and livestock products. Finally, it can transform the waste into resource and energy and the waste can be used repeatedly. Recycling and reuse of waste can not only control environmental pollution and bring economic benefits but
also optimize society’s investment structures.

2 Emphasize the multi-functions of agriculture, besides production

In China, ecological agriculture emphasizes horizontal coupling with different agriculture production processes in order to achieve the goal of increasing yields. For example, species diversity is not only useful for reducing crop pest disease, but can also increase crop yield. It is proved by some studies that compared with only planting high quality rice, inter-cropping different kinds of rice can prevent against rice blast 81.1%–98.6%, reduce pesticide usage by more than 60%, and increase the yield per hectare to 630–1040 kg (Zhu et al. 2000). Through investigation and experiments based on small scale products it has been shown that the net income of the rice-fish system is 2144 CNY hm⁻² higher than traditional monocropping, due to product diversity (Li 2009).

Natural vegetation is continuously being reduced across the world and environmental problems are increasingly apparent. Agriculture ecosystems can provide other services and functions besides food production, such as regulation of atmospheric chemical composition, flood storage and purification (Li 2008). In 1997 American ecologist Costanza showed that the global farmland ecosystem services per year was about 128 billion USD, and accounted for 0.3% of all global ecosystem services (Costanza et al. 1997). The value of ecological rice farmland ecosystem services is always higher than conventional monocropping. For example, a rice-fish system has its own advantage such as carbon fixation and oxygen release, nutrient retention, pest prevention, water regulation and tourism. This system’s external economic increase is 2754 CNY hm⁻². At the same time, rice-fish systems can also reduce CH₄ emissions and reduce the need for fertilizer and pesticide, reducing external negative economic value by about 4693 CNY hm⁻². In total the economic value of a rice-fish system is 7447 CNY hm⁻² higher than conventional rice monocropping (Liu et al. 2010). However, the external benefits are not reflected in the market. The comprehensive effects of ecological agriculture cropping are underestimated and there is no incentive for farmers to adopt ecological and environmentally friendly production. Therefore, there is a high need to form the mechanism for purchasing ecosystem services and ecological compensation. By calculation, if the government can give farmers 1136 CNY hm⁻², it can effectively encourage them to carry out the rice-fish system, while the type of farming can produce ecosystem services to the value of 16 045 CNY hm⁻². This is a win-win not only between farmers and the government, but also between ecological and economic effects (Liu et al. 2010).

In China, agriculture has strong natural and socio-economic regional characteristics and forms rich and varied agricultural areas from north to south. It not only reflects the diversity of nature, but also is the basis of culture diversity. It is possible that the main function of ecological agriculture moves away from the production function to the complex functions of ecology and production. At present, there are many different interpretations of agricultural multi-functionality across the Organization for Economic Cooperation and Development (OECD) (Bresciani et al. 2004), United Nations FAO (FAO) (Renting et al. 2009), World Bank (World Bank 2004) and domestic scholars (Sun 2010; Sun et al. 2008) proposed their own classification system. Common to all definitions is that the development of a modern ecological agriculture should emphasize the overall improvement of economic, ecological and social benefits and should break out the restrictions of single and narrow industry. It should provide a variety of material to meet consumer demand and also cycle organic matter in the system to result in high economic and environmental benefits. Last, it should play a role in eliminating poverty in rural people and assist rural labor employment.

3 Integrate traditional essence and modern technology

China’s ecological agriculture has attached importance to the transmission of traditional knowledge not only inherit and carry forward the essence of traditional agro-techniques. Modern sciences and technologies should be adopted while paying attention to ecologically optimizing the agro-technique system and integrating techniques through a series of typical ecology engineering models. These practices provide basic ecological frameworks and technology prototypes for realizing a healthy transition from traditional agriculture to modern farming and then establishing high-yield, high-quality, high-benefit environmentally friendly and sustainable agriculture.

Ecological agriculture is currently focused on mining the cream of traditional agriculture techniques and emphasizes the utilization of agricultural waste. In rural areas, based on rural energy integrated construction, many households make use of biogas as the ligament of eco-agriculture practice. Stereo planting has been advocated in crop farming, and diversified management has been put in practice to improve land productivity. Effective integration has been stressed in mega-agriculture systems, including farming, forestry, animal husbandry, fish and other sectors. To avoid agricultural environmental deterioration and the diminishing returns of external investment induced by intensive agriculture, it has become urgent to promote the modernization of agriculture development and realize ecological rationalization simultaneously.

Ecological agricultural development requires exploring how to coordinate economic and ecological environmental
protection, and developing leading industries with comparative advantages in the market. Industrial structure should expand into the first, second and third industry from planting, breeding and processing industries, and then through scientific and effective links between different industries and sectors perfect local clean production systems. High-tech enterprises should play a leading role in ecological agricultural development and popularize eco-agricultural techniques via typical demonstration effects, good performance and easy promotion, and tap the potential of and improve traditional technologies. Efforts will be continued to import and apply advanced technologies, especially pollution-free technology. High-tech sectors should develop ecological agriculture through geographic information systems and other modern technologies, which help to realize the reasonable layout of ecological agriculture. Popularization of various ecological agriculture techniques such as biogas and comprehensive utilization of waste technology, bio-control pest technology, stereo planting and breeding technology is needed. Other agricultural development models and practices such as the combination of precision agriculture technology should be applied.

Ecological agriculture techniques should focus on high-tech development. In order to perfect and improve the virtuous circle of the ecological agriculture system, “plant production, animal transform and microbial reduction”, (i) we should develop and research interface techniques based on microorganism technology; (ii) optimize and assemble modern production techniques scientifically and reasonably using engineering methods; (iii) regulate agricultural production behavior to protect the agricultural ecological environment, improve agricultural product quality and realize sustainable development; (iv) we should establish technical specifications systems of new types of production and ecological protection technology, at the same time searching leading industry which has comparative market advantage and could coordinate the development of the economy and ecology. Forming a network for sustainable ecological agriculture industry is the hotspot of ecological agriculture based on establishing and perfecting environmental and product quality monitoring systems and local and macro-control management systems.

4 Pay attentions to brand development and focus on both quantity and quality

China has a vast territory and many ethnic groups and has created and accumulated a number of traditional techniques, innovations, practices, folk arts and traditional religious culture. Features such as mythological mountains and forests, geomantic areas and other protection practices, which play an important role to conserve biological diversity, make use of biological resources sustainably, improve food quality and guarantee food safety (Xue et al. 2009). ecological agriculture reduces chemical fertilizers, pesticides, animal debris and other pollutants which could contaminate water and soil, adjust ecological relationships and ecosystem structure and function and make use of mutual beneficial symbiotic relationship of various components. It could provide more ecosystem services and weaken negative effects compared to conventional farming, and also has natural advantages of producing high quality agricultural products. For example, in a rice and fish symbiotic system, fish stir the soil and the respiration of weeds and plankton decrease, leading to a 31.42% reduction in methane emissions per unit area (Xiang et al. 2006). Fish waste contains nitrogen, phosphor and other nutrients and supplies essential nutrients for rice tillering, booting and resistance to lodging, increasing P by 7.32 kg P and N by 2.19 kg N per hectare (Zhang et al. 2009). This system reduces the use of nitrogen and phosphorus fertilizer. Some insect pests of rice have been controlled such as Tryporyza incertulas, Cnaphalocrocis medinalis Guenée, rice delphacidae and rice leafhopper; meanwhile total biomass of weeds decreases by nearly 90% (Berg 2001) and further reduced the need for pesticides.

High-quality agriculture includes organic agriculture, green agriculture and pollution-free agriculture. These agricultural products are characterized as high quality and do not use products obtained by genetic engineering in the process of production and require less chemical pesticides, fertilizers, growth regulators, feed additives and other materials. These practices coincide with the principles of ecological agricultural development. In recent years, high-quality agricultural product in China has made great progress, but in general it is still in the early stages of development. The Government’s supervision on farm product safety is not well regulated. In many areas certifications for green food, pollution-free food and organic food are in a state of chaos, and even counterfeit products appear in the market place, which seriously impacts upon the image of ecological agricultural products and the healthy development of ecological agriculture. The development of high-quality agriculture needs to establish interest in a broad community composed of enterprise, households, markets and governments which clarify their respective obligations and rights, deal with various risks in agricultural production and enjoy ecological agriculture products. We can adopt several models in practice, including an agricultural company model, cooperative model, contract model and professional association model. Agricultural company is a joint company, composed of households, factories and business, which is a vertical integration organization of production, material supply and selling. Cooperative society models include co-production of farming and animal husbandry, cooperation of product processing and selling, cooperation of business management and technical
with local characteristic, climates, regional types and abundant agricultural products regional, processing technology, cultural, national, safety and ecological characteristics. China has various natural climates, regional types and abundant agricultural products with local characteristic, however it has few brands of great influence, especially lacking global brands such as Chinese silk. We should promote the development of ecological agriculture through branding strategies.

5 Attach great importance to industrialization

With the development of a market economy the conflict between peasant economy and mass market has become more prominent. Small scale production, a high degree of decentralization, and production methods and technologies can not adapt to the high diversity requirements of the market and industrialization has become an important feature of ecological agriculture (Wang et al. 2001). The ecological agriculture industry was targeted in China’s harmonious development of man and nature, which is based on market demands and relies on local ecological resources, actualized regional distribution, specialized production, large-scale construction, serial processing, integrated operation, socialized servicing, enterprising management, harmonious agricultural production, economic development and environmental protection. On the whole, ecological agriculture has developed in China in recent years, but remains at a low level and in an initial stage (Zhang 2000). The development environment for ecological agriculture is still weak. Agricultural enterprises, rural economies, farmer quality, and infrastructure and industry awareness still need to be promoted and completed. Based on the positive and negative experiences in the development of China’s ecological agriculture, the lessons learned reveal that we should be looking at international markets, specifying product standards, examining regional characteristics, exerting brand effects, regulating production bases, developing value-added processing and enhancing competitiveness.

Industry chains are the goal of industrialization. Cycling of industry chains was an important feature of China’s ecological agriculture, which focused on material recycling and the step by step use of energy through the reasonable linking of industries. The cycling of industry aims to minimize ecological agricultural waste, maximize the utilization of agricultural resources, achieve resource efficiency, environmental friendliness and a good economy. An extension of industry chains includes information sharing, technology servicing, technique designing, logistics network, and tourism services. Making the products, production, market selling plans and multi-level product systems such as popular products, ecological products, green products, organic products, regional products, featured products for different consumer groups. Mass production bases was an important feature of ecological agricultural industrial systems. China’s ecological agriculture has followed the principle of unified planning, rational distribution, relative concentration and contiguous development. We should build a batch of distinctive pollution-free agricultural production bases according to different natural resources, the foundations of social development and overall planning of agricultural industrialization. The environmental quality of the production base should be strictly controlled and a green labeling system should be implemented. Last, we should expand value-added processing and enhance competitiveness.

Standardization is a key problem in ecological agricultural development, mainly reflected in the environmental standards of production areas, standard of means of agricultural production, standard of agricultural production and agricultural product standards. The environmental qualities of production areas are an important prerequisite and ensure foundation of product quality; standards of means of agricultural production are focused on the features and application effect of pesticides and fertilizers, which guarantee the ecological agriculture industrial system from the source. Agricultural production standards are standards in the production process, including application methods, processing and preservation specifications, agricultural products standards including appearance standards, quality standards, and nutrition standards, safety standards and health standards. Standardization of ecological agriculture should refer to international standard ISO14000, HACCP (Hazard Analysis Critical Control Point), and we should build our own system of national and regional standards, reflecting a high, medium and low multi-level quality standard system that meets multiple social needs.

6 Focus on cultural heritage and the sustainable development of rural areas

China’s agricultural civilization has been extended in the development process during recent years. Agricultural products in any region have a specific background and connotation in cultural, historical, geographical and humanistic terms; they all have regional characteristics and national culture. Rational use of these resources plays an important role in developing local economies, inheriting and transmitting cultural heritage, promoting history and enhancing national self-confidence (Luo 2009). However this traditional knowledge is in danger of disappearing
due to the penetration of modern civilization. China’s ecological agriculture is built on the hesitation towards improving traditional agriculture. The promotion of ecological agriculture will help guide local governments in regions inhabited by ethnic groups promoting national culture, and reduce the loss of traditional knowledge so that it can be used the future economic development. The FAO has started the “Global Important Agricultural Heritage System (GIAHS)” program, the Chinese rice-fish system became one of the first five protection plots and this status provides a new growth aspect for local agricultural economic development.

The key point of cultural heritage is finding and protecting agricultural heritage. Firstly, we should start agricultural heritage and intangible cultural heritage rescue excavation across the nation; we should accept the village as the main unit of agricultural heritage, make a comprehensive display of traditional crafts, traditional technology, and traditional life. Second, enhance protection by actively using traditional technologies as these represent a new kind of interest mechanism and will motivate farmers. Protection and utilization are closely related (Min et al. 2007). The protection of agricultural heritage and market development are closely related. A moderate concentration of heritage systems, labor system division, market expansion, the generation of economic benefits all enhance the protection of heritage and form a virtuous cycle. The heritage of traditional culture creates a new agricultural civilization and market demand is important. We should make agriculture continuous and sustainable through differences in planning and creative planning

China’s ecological agriculture is based on the coordination of the relationship between man and nature. The main targets are the promotion of agriculture, rural economies and sustainable development. We should use multi-objective integrated decision-making instead of conventional single-target production decisions in order to achieve ecological economic cycles, and unify ecological, economic and social benefits. Our ecological agriculture was not only a strategic decision, but also a sustainable development mode in rural areas, and included the construction of different types of ecological economic systems, production components, population structure of plants and animals, local ecological and economic conditions, integrated eco-technology and corresponding management. Application to sustainable development can be done at the micro-scale (e.g. courtyards of ecological agriculture systems and multi-component greenhouses), meso-scale (compound management farmland ecosystems), macro-scale (watersheds) and regional scale (village, county). There is a problem of scaling when promoting successes at the micro-scale to a larger scale and scientific research is needed in this area. We should not neglect the development of ecological agriculture when we stress the construction of ecological counties, it is the only way to mobilize the masses and achieve broad participation of different sectors of society.

China’s eco-agriculture is rooted in traditional culture and long-term practical experience and combined with natural, social and economic conditions coincidental to basic ecology and ecological economic theory. China’s system has provided a way of adapting to sustainable development to solve problems in the course of agricultural development. Taking a wide view across mainstream models, agricultural production has greatly improved productivity on the one hand, but has brought about uncertainty regarding the ecological environment impacts. Some of these uncertainties have become a threat to biodiversity and human survival. However, existing farming culture over thousands of years deserves careful excavation, conservation, research and improvement. Facing the new century China will adhere to the scientific development paradigm, integrate traditional essence and new technology with continuous creation and improvement, and explore a sustainable development pathway with Chinese characteristics.

Acknowledgements
The authors would like to extend their gratitude to YANG Yangang, ZHANG Canqiang and LUN Fei for help preparing this paper.

References

中国生态农业的发展与展望

李文华，刘某承，闵庆文

中国科学院地理科学与资源研究所，北京 100101

摘要：农业是国民经济的基础，在通过科学技术进步和土地集约化利用取得巨大成绩的同时，也造成了生态与环境问题的日益加剧。在这一形势下，人类社会开始反思农业发展的政策、模式和技术，认识到农业的发展，不仅要提高产量以满足人们对农产品的数量需求，还要提高产品质量，保证食物安全，发挥生态系统的多种功能。20世纪末，中国生态学家和农学家共同提出了具有中国特色的生态农业概念。经过近30年的实践和发展，中国生态农业建立了较为完善的理论体系，总结了适应中国国情的成功模式，开展了不同层面的生态农业建设试点，取得了显著的成效，并得到国际社会的广泛承认与赞扬。但也存在一些问题，如对农业的多种生态服务功能没有给予充分的重视，缺乏市场化引导、规模化经营、专业化生产和品牌化推广等。面对着新时期社会经济发展特点与资源环境瓶颈，中国生态农业需要在产业循环、多功能化、高品质、产业化以及融合传统精华与现代技术、实现农村可持续发展等方面多做努力。

关键词：生态农业；循环农业；多功能农业；高品质农业；农业产业化；农业文化遗产


