Ecoagriculture in China: A Systems Approach

LUO Shiming

Institute of Tropical and Subtropical Ecology, South China Agricultural University, Guangzhou 510642, China

Abstract: Ecoagriculture in China began in the late 1970’s/early 1980’s. This system aims to bring about the most effective coordination of social, economic and ecological factors in agricultural practices. Key approaches include ecological planning at the landscape level, cycling system design at the ecosystem level, and the re-establishment of the importance of biodiversity. The social and economic environment favoured for ecoagriculture is important in order to enable its development. For the social environment, it is important to set up the necessary moral standards involved through educational, legislative and evaluation systems. For the economic environment, efficient government subsidy policies, an effective market system to deal with pollutant discharge, and efficient markets for the sale of ecologically-friendly products.

Key words: ecoagriculture; agroecology; cycling, biodiversity; ecological subsidy; policy; ecological legislation; China

The practice of Ecological Agriculture (Ecoagriculture) began in China in the late 1970’s and early 1980’s. There are currently more than 400 counties in China that have introduced and practice ecoagriculture (Luo 2009). With the experiences gained over the years it is now time to consider the results, re-organize our thoughts, and where possible, to promote and extend the practice of ecoagriculture in a more clearly defined development path.

1 Developing ecoagriculture: the most important tasks

It has been suggested that ecoagriculture can include anything in agriculture, but this simply confuses the people who intend to practice this system. It is, therefore, important to point out what the key practices in ecoagriculture involve and where our efforts should be focused.

According to the cybernetic theory, three levels for the control and regulation mechanisms of agroecosystems can be identified (Luo 1987): (i) the natural regulation mechanism; (ii) the direct control by human activities; and (iii) indirect regulation of the social and economic structure (Fig. 1).

Thus, two key tasks for ecoagricultural development need to be taken into account. The first is to establish the farming practices to reconstruct an agroecosystem with emphasis more on natural regulation mechanism. The second is to form a social and economical environment which will benefit those actions.

1.1 Ecoagriculture: farming practices

According to the organization level, natural systems can be divided into individual, population, community, ecosystem, landscape, regional and global levels. In landscape, regional and global levels, the most important action for ecoagriculture is ecological zonation. At the ecosystem level, the most important action is to convert the wasteful straight line production system back to a recycling system. At the community, population and individual levels, the most important action involves rebuilding the rich biodiversity relationship and reducing external input (Fig.2) (Luo 2008).

1.2 Ecoagriculture: social and economic environment

Human’s activities are motivated by the individual’s judgment of justice and/or benefit to oneself.

In order to build up a moral system in society that is strongly adapted to sustainable development, it is important to inform and teach citizens using available educational systems and public media, and to regulate certain practices
using legislation. The education system and public media can help to form new behaviour strategies for the people by means of increased knowledge and moral standards; the legislative system will regulate the implementation of the laws, which should reflect the mainstream moral standards of society. The assessment standards regulating ecoagriculture, eco-village, green food, organic food, etc., can in fact help in teaching farmers what are good agricultural practices, and guide their current practice toward these standards.

Market failures and economic externalization in ecological services must be adjusted through direct economic measures or indirect environmental rights assignment in order to reflect the true social costs and benefits. Direct economic measures include ecological compensation such as heavy taxation for the use of limited natural resource and high compensation fee for pollution discharge, and government subsidy for ecologically sound practices such as government financial investment policy for pollution control projects and reforestation projects. These government economic policies will internalize the external ecological/environmental costs/benefits caused by economic activities. According to the Coase Theorem, the assignment of environmental rights for resources and environment will be able to use market force rather than government control to internalize those externalized economic cost and benefit (Wang 1997). According to this theory, markets for environmental rights should be set up for pollutant discharges such as BOD, SO₂, CO₂, etc. (Fig.3).

2 Ecological zonation
The ecological services provided by nature cannot be driven only by market forces. If we divided the ecological services into provisional, regulation, cultural and supporting functions, the market force usually drives the...
system in the direction of more provisional services and towards less other services. A correct ecological zonation can only be made by a well coordinated multidisciplinary decision-making team. Government, community leaders or company leaders in charge of land use should take responsibility for organizing the planning activity. The ultimate goal of ecological zonation is to coordinate the multiple functions of a land-use system including biological conservation, ecological safety, environmental protection, food security, job security, economic development, cultural activities, and daily life through land-use assignment. The relationship of land use among transportation, residential areas, industry, agriculture, forestry and natural conservation can be decided and presented in a map. In addition, agricultural production should be optimized in the zonation.

A watershed is a good ecosystem for ecological zonation. For example, in the typical top-down arrangement in the hilly areas of southern China, includes conservation forestry, economic forestry, orchards, terraces, crop fields, lowland fish pond and dike systems, high bed-low dish system, shelter-belt system and mangrove system. This typical agricultural watershed arrangement can adapt well to the humid and hot climate in the region (Fig. 4). Similar ecologically sound watershed arrangements have also been identified in other regions of China (Li 2003).

3 Recycling system design

Traditional agriculture in China used to have rich internal cycling paths. The traditional fish pond and dike systems in the Pearl River delta are one example in which mulberry leaf feeds silkworm, and silkworm waste feeds fishes in the pond, pond mud is returned to dike each winter. However, industrialized agriculture overemphasizes land output and labor output efficiency, overemphasizes economic returns and market forces. Large amount of industrial input such as overuse of chemical fertilizer and pesticide can cause environmental pollution and food pollution in many cases. The blue green algal bloom in Taihu Lake 2007 and the red tide events along the coastal area of South China Sea and Bohai Sea, the high dosage of nitrate detected in vegetables and groundwater are all strong signals of the negative effects of the increased input levels of fertilizer to agriculture in China. Obviously, this development can not continue (Fig.5).

The re-introduction of a recycling system for agriculture will include different scales of cycling paths. Crop – Field path concentrates on the cycling of stalk and straw. Live stock – Field path focused on the cycling of animal waste. Village – Field path focused on the cycling of wastewater and garbage generated by the nearby village. Industry – Field path mainly refers to organic waste from those industries that process agricultural products. City – Field path uses city organic waste and sludge from sewage water treatment, and the Global – Plant path relates to the carbon

Fig. 4 A typical watershed arrangement in southern China.
From top down: conservation forest, economic forest, orchard, horticulture garden and crop field, dike pond system, high bed – low ditch system, shelter-belt system, and mangrove forest along seashore.
absorption process (Fig. 6).

Straw burning is quite common in rural areas. It not only causes nutrient lost, but also causes air pollution. Many well-developed methods can be used for straw recycling. Besides the direct return of straw through physical, chemical and biological decomposition processes, such as compost, straw is also widely used as animal feed and as a mushroom production medium in China. Livestock waste is often used after composting and through anaerobic fermentation in a biogas tank. In China, the use of biogas tanks has increased rapidly over the past ten years, due to the financial subsidy provided by the government. In 2007, there were about 26.5 million rural families with biogas and more than 1600 medium and large animal farms using their own biogas systems. This is equivalent to 16 million tons of standard coal. Green house – Livestock – Biogas – Crop systems are widely used in northern China, and Livestock – Biogas – Fruit systems are widely extended in South China.

Small-scale wastewater treatment facilities are important for livestock production and sewage water from the villages. Although artificial wetland technology for wastewater treatment is quite well-developed, so far it has not been widely adopted in rural areas because of its cost.

4 Reconstruction of biodiversity relations

In industrial agricultural systems, the species other than the target crop or animal are usually considered to be eliminated in order to avoid nutrient competition or to avoid large pest outbreaks. This has resulted in increasing amounts of the pesticides and antibiotics being applied (Fig. 7). This practice not only causes food and environment contamination but also increases the use of fossil fuels and other resources. However, low carbon agriculture can be achieved through the reconstruction of biodiversity relations.

4.1 Biodiversity landscape design

Many studies have shown that the orchard or crop field close to “natural vegetation” contains fewer pests and more natural enemies (Huang 2008). The “natural vegetation” includes permanent forest, wind-break systems, weed-
covered field borders and irrigation channels, etc. A patchy or mosaic arrangement of field crops can also efficiently reduce the outbreak of pests and the negative effects of Bt crops on the elimination of natural enemies because of the lost of prey (Fig. 8).

4.2 Cropping system design
There are many good cropping systems in China, e.g. intercropping of short leguminous crops like soybean with tall cereal crops such as corn, rubber plantations intercropping with tea, Paulownia intercropping with wheat, jujube (Ziziphus jujuba) intercropping with wheat, mixed pond cultures of grass carp, big-head carp, common carp, and silver carp, paddy rice rotated with upland crops, rice varieties resistant to rice-blast disease intercropped with traditional rice species that are vulnerable to blast disease (Lu 1999; Zhu 2007). A great deal of progress has been made in identifying the mechanisms that result in mutual benefits to these systems. The niche differentiation among the different species involved is one of the most fundamental principles for the successful design of these cropping systems.

4.3 Food chain design
The rice-duck and rice-fish systems are two examples of positive food-chain design. These systems effectively control weeds and other types of pests, and at the same time they can reduce the necessity of chemical input to the systems. The release of natural predators for pest control such as Chrysopsa perla which preys on cotton bollworm, and ladybug which preys on aphids, are only two examples that can help increase the effectiveness of the predatory food chain. Breeding earthworms and fly larvae in animal waste and crop straw are examples which can help to extend, broaden, and speed-up the detritus food chain (Li 2003). However, in some cases, it is necessary to make a “cut-off” in the food chain. For example, on contaminated fields, food crops are seldom an alternative for land use, in which case, the land can be put to a better use when utilized for lawns, flower growing, and/or tree growing.

4.4 Beneficial/harmful mutual relation design
Traditional farmers have rich knowledge and experience on the relationship between plants, insects and animals. Some of this knowledge has proven to be of value to science and is being used today. Perilla frutescens is currently used as an effective insect repellent in greenhouses in the Guangxi Region and Chinese wing nut (Pterocarya stenoptera) is used to attract locusts from nearby mulberry gardens in Guangdong Province. Ageratum conyzoides L. is planted under citrus trees as a cover crop in southern China. This species provides shelter and food for predator mites which in turn control the harmful red mite. The plant is also used as green manure (Huang 2008). Research has indicated that corn can attract natural predators and can thus help control cotton bollworm and aphids in nearby cotton fields (Wang et al. 2005). Traditional Chinese literature recorded the use of sesame, hemp, green onion (Allium fistulosum), Chinese chives (Allium tuberosum), garlic (Allium sativum) or cabbage mustard (Brassica alboglabra) which can all repel insects from a number of crops (Zhou 1998).

According to ancient Chinese literature the phenomenon of allelopathy was widely recognized by farmers at a very early date. For example, they used sesame to control weeds in newly reclaimed land. Weeds can also be suppressed by the use of Chinese cinnamon (Cinnamomum cassia). The spread of bamboo through rhizomes can be controlled by cultivating reeds (Phragmites australis), Rhizoma Chuanxiong (Ligusticum chuanxiong Hort.), Gleditsia sinensis Lam. or Mucuna sepervirens Hemsl (Zhou 1998).
The genes, varieties and species which have resistance to environmental/biological stress have been identified and used in agricultural production systems for many years (Zhu 2007) and they will continue to play a key role in the future of eco-agriculture in China. Many of the resistant gene pools will originate from traditional varieties or wild species.

5 Motivation and moral justification of eco-agriculture

It is important to set up an evaluation system in society which strongly motivate and justify broad ecological and environmental responsibility on the part of every individual. Three major aspects of this system are: 1. education; 2. legislation; and 3. evaluation standards for the production process and for the products.

5.1 Education

Environmental and ecological education in China has improved significantly in the formal education system, and the relevant content in educational textbooks for biology, chemistry, physics and geology, both in primary and middle schools has improved (Zhu & Deng 2005). However, more specific education for students in rural areas on the subject of eco-agriculture still needs major improvement (Zhang 2002). There are environmental and ecological courses such as introduction to environmental sciences and fundamental ecology are provided as public courses for all students at many universities. The course in agro-ecology for agricultural major students is the only formal course covering the principles and methods of eco-agriculture in China. In addition, the principles of eco-agriculture have also been included in other courses such as plant protection, plant nutrition, crop cultivation, cropping system etc.

Public media, e.g. television, radio broadcasts and newspapers, have recently begun to pay more attention to ecological and environmental issues. These information sources also expose and criticize incidents and problems related to the environment. The special column “Circular Economics” appeared in the newspaper network of “Farmer’s Daily” (www.farmer.com.cn) provides news and information on eco-agriculture. The CCTV has a channel specifically for farmers and agricultural issues (http://space.tv.cctv/podcast/nongguangtiandi). However, a search of these sources showed that only a few of the subjects discussed were related to eco-agricultural practices.

Direct training and extension training for farmers are the most effective means to provide them with the necessary education. Although the “Law for Agriculture Extension” was initiated in 1993, some extension stations in rural areas were still involved in promoting the use of pesticides and chemical fertilizers and seeds, due to the high commissions granted by industries and commercial companies. In 2006, a document “State Department on Deepening the Reform and Strengthening Agriculture Technical Extension System in Rural Area” was put forwarded. This document attempted to separate the public non-profit services from profit related services. However, there is still a lot to be done in this area even today.

5.2 Legislation

The Chinese Constitution, Environmental Protection Law and Agricultural Law, proposes principles for the protection and improvement of agriculture and the rural eco-environment. Detailed regulations for the protection of air, water, forests, fish, wildlife, land and soil are prescribed in separate specific laws. The “Law of the People’s Republic of China on Promotion of Cleaner Production” was adopted in 2002, and the “Circular Economy Promotion Law” was activated in January 2009. These laws provide an effective framework for eco-agriculture. However, more specific and more detailed regulations are still needed.

5.3 Evaluation standards

The Chinese Ministry of Environmental Protection proposed two standards “The Evaluation Standard for Ecological Villages (2006)” and “The Evaluation Standard for Ecological County (2007)”. These standards define detailed levels of sewage-water treatment, stalk recycling, animal waste recycling, natural vegetation cover, and healthy food production. A reduction in pesticide and fertilizer use and an increase in soil organic matter are also proposed. However, the more specific “Evaluation Standard for Eco-agriculture” issued by the Ministry of Agriculture in 1994, did not cover requirements for ecological planning, recycling index, biodiversity, environmental quality and/or food safety. Obviously, this standard needs to be updated.

6 Economic motivation

Direct compensation and/or subsidies are effective ways to overcome the economic externalization of agricultural production activities. In China, a subsidy for public conservation of forests was initiated in the late 1990s. Compensation for returning hilly cultivated areas to their natural vegetation was begun in the year 2000 in northwest China. The government also subsidizes farmers for the construction of biogas tanks for recycling waste. However, the government has also subsidized the purchase of commercial fertilizers and pesticides since 2006, in order to alleviate the effects of the rising prices for these products, which in turn are driven by the increased price of oil. Clearer directives for government subsidies and stronger stimulation of eco-agricultural practices need to be achieved in forthcoming policy adjustments.

The market for the discharge of pollutants is still at the
experimental stage in China, and the “Clean Development Mechanism” (CDM) introduced in the Kyoto Protocol could be widely used in agriculture, and especially in forestry. By 2008, 1200 CDM projects were approved in China. Financial support made available was mainly used for reforestation, hydropower, wind power, solar energy, and biogas projects. Mechanism similar to CDM can also be set up within China between city and rural areas or between eastern and western China in the future.

In general, eco-agriculture in China has made great progress. Future development will, however, depend on the recognition and implementation of key practices, including agro-ecological planning, cycling agro-ecosystem design, and the re-establishment of important biodiversity in agriculture. The future of eco-agricultural development will also rely heavily on favourable legislation, economic and moral environment created by government and society.

References