A System Approach toward Ecoagriculture in China

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Abstract: *Ecoagriculture in China began from the late 1970's. It aims at the best coordination of the social, economic and ecological effects in agricultural practices. The key approaches include ecological planning at the landscape level, cycling system design at the ecosystem level and the reconstruction of biodiversity relations at lower levels. The favoured social and economic environment is important to enable the development of ecoagriculture. For the social environment, it is important to set up moral standards through educational, legislation and evaluation systems. For the economic environment, it is important to set up a good government subsidy policy, a good market system for pollutant discharge and for ecology-friendly products. The situation in China is further discussed.*

Keywords: *ecoagriculture, agroecology, cycling, biodiversity, ecological subsidy, policy, ecological legislation, China*

Ecological Agriculture (Ecoagriculture) practice began in China from the late 1970's and early 1980's. At present there are more than 400 counties in China that are practicing ecoagriculture (Luo Shiming 2009).
After practicing ecoagriculture in China over these years, it is the ripe time to re-organize our thought and push ecoagriculture to a more clear development path.

What are the most important tasks for the development of ecoagriculture?

Some say that ecoagriculture can include anything in agriculture but this confuses many people who want to practice it. It is important to point out where the key practices in ecoagriculture are and where our effort should be focused.

According to the cybernetic theory, there are three layers of the control and regulation mechanisms of agroecosystems that can be identified (Luo Shiming, 1987). The first layer is the natural regulation mechanism. The second layer is the direct control by human activities, and the third layer is the indirect regulation of our social and economic structure (Fig. 1).

Accordingly, there are two key tasks for ecoagriculture development. The first one is the farming practices to reconstruct an agroecosystem with biodiversity. The second one is to form a social and economical environment which will benefit those actions.

Figure 1. The three layers of agroecosystem control and regulation mechanism.

(1) Farming practices for ecoagriculture

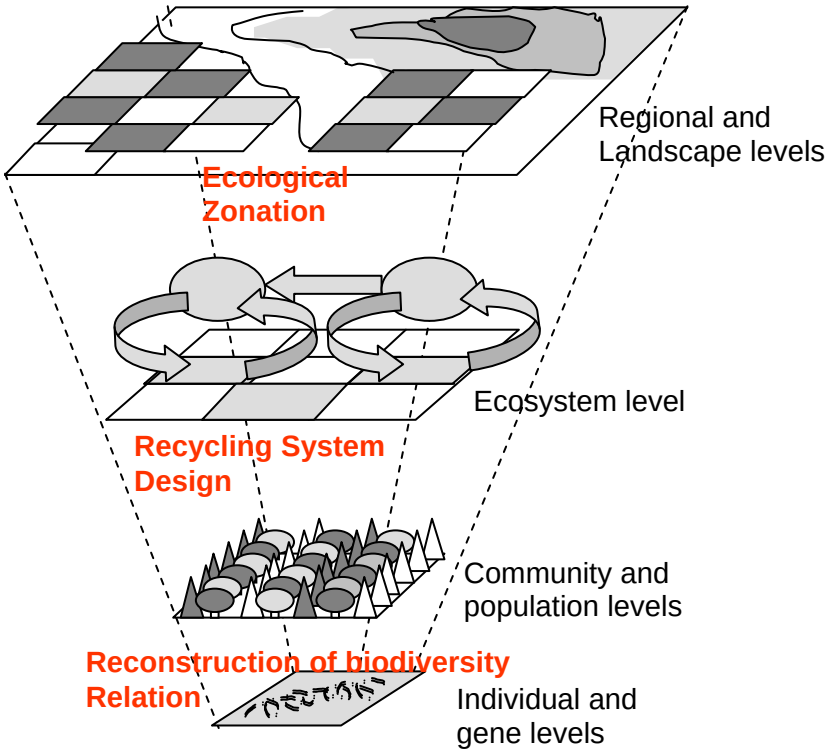

Figure 2. The major farming practices for ecoagriculture (Adapted from Luo Shiming 2008).

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 community, population and individual levels, the most important action is to rebuilt the rich biodiversity relationship and reduce external input (Fig.2) (Luo Shiming, 2008).

(2) Social and Economic environment for ecoagriculture

A human's activities are motivated by his/her judgment of justice or own benefit.

In order to build up a moral system of the society which is adaptable to sustainable development, it is important to teach people through our education system and public media, and to regulate their behaviour through the legislation system. The education system and public media can regulate the behaviour of the people from the knowledge and moral standard they learn, and the legislation system will regulate the behaviour from law implementation which reflect the mainstream moral standard of society. The assessment standards for ecoagriculture, eco-village, green food, organic food etc., can actually teach farmers what is good for agricultural practice, and guide their practice toward these standards.

Market failure and economic externalization in ecological service must be adjusted through direct economic measure or indirect environmental right assignment in order to reflect the true social cost and benefit. Direct economic measures include the ecological compensation such as taxation and fee collection, government subsidy level, or government input policy which will internalize the external cost and external benefit of individual activities. According to the Coase Theorem, the environmental right assignment will change an external theme into an internal one (Wang Jinnan, 1997). According to this idea, markets for environmental right should be set up for the pollutant discharge such as BOD, SO2, CO2 etc. (Fig.3)

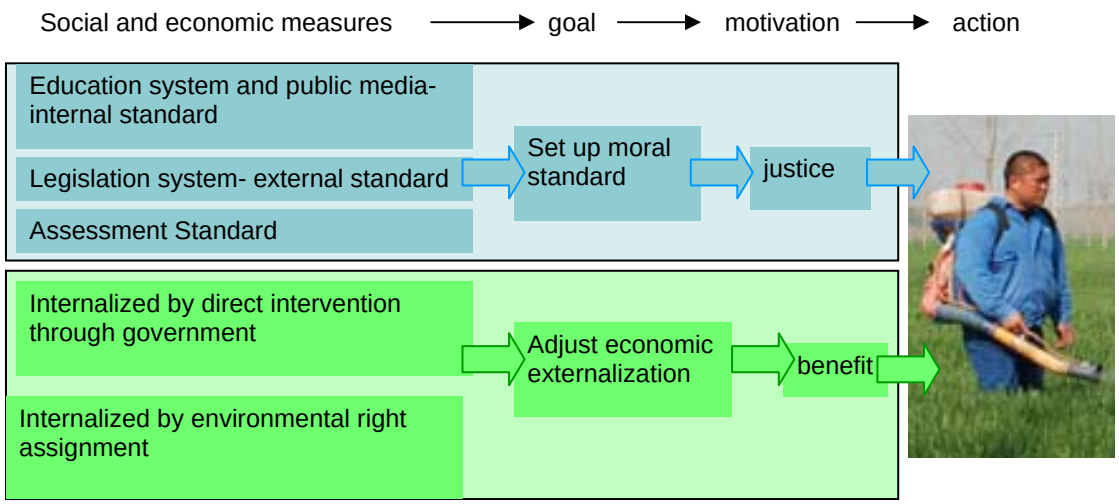

Figure 3. Major social and economic measures to promote ecoagriculture.

Ecological zonation

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

A watershed is a good ecosystem for ecological zonation. For example, the typical arrangement from top-down direction in the hilly area of South China, there are conservation forestry, economic forestry, orchard, terrace, crop field, lowland fish pond and dike system, 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 ecological sound watershed arrangements have also been identified in other regions of China (Li Wenhua, 2003).

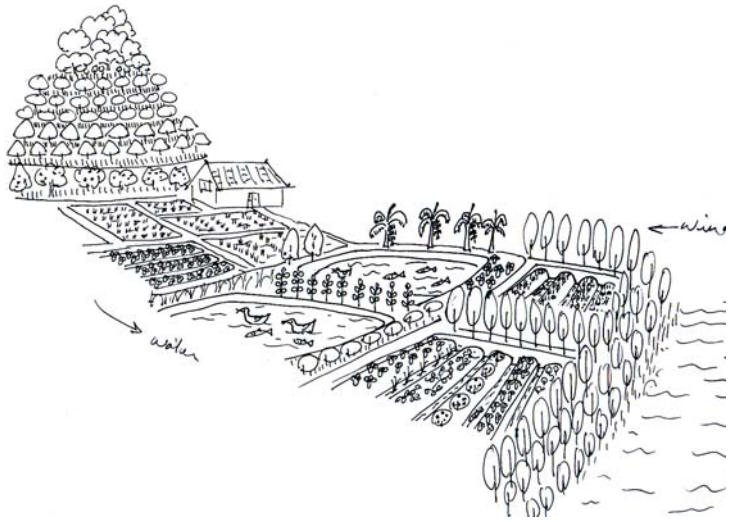

Figure 4. A typical watershed arrangement in South China.

From top down there are 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 sea shore.

Recycling system design

Traditional agriculture in China used to have rich internal cycling paths. Traditional fish pond and dike system in the Pearl River delta is one of the example which mulberry leaf feeds silkworm, and silkworm waste feeds fishes in pond, pond mud is returned to dike each winter. However, industrialized agriculture over-emphases land output and labor output efficiency, over-emphases economic return and market force. Large input not only increased agricultural production, but also increased environmental pollution and food pollution. The blue green alga bloom in Taihu lake 2007, the increasing red tide happened along the coastal area of South China Sea and Bohai See, the high dosage of nitrate detected in vegetable and underground water have given us a strong signal that agriculture in China could not continue the same way (Fig.5).

The rebuilding of 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 focuses on the cycling of animal waste. Village – Field path refers to the cycling of waste water and garbage generated by the nearby village. Industry – Field path mainly refers to organic waste from industries which processing agricultural products. City – Field path use city organic waste and sludge from sewage water treatment, Global – Plant path refers to the carbon absorption process (Fig. 6)

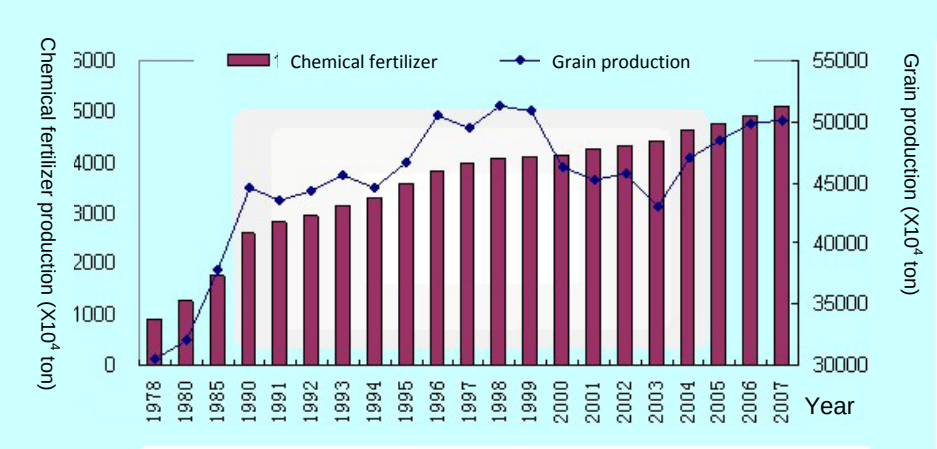

Figure 5. The chemical fertilizer used and grain production in China.
(source: http://www.hnxlx.com.cn/news.php?fid=17&id=145)

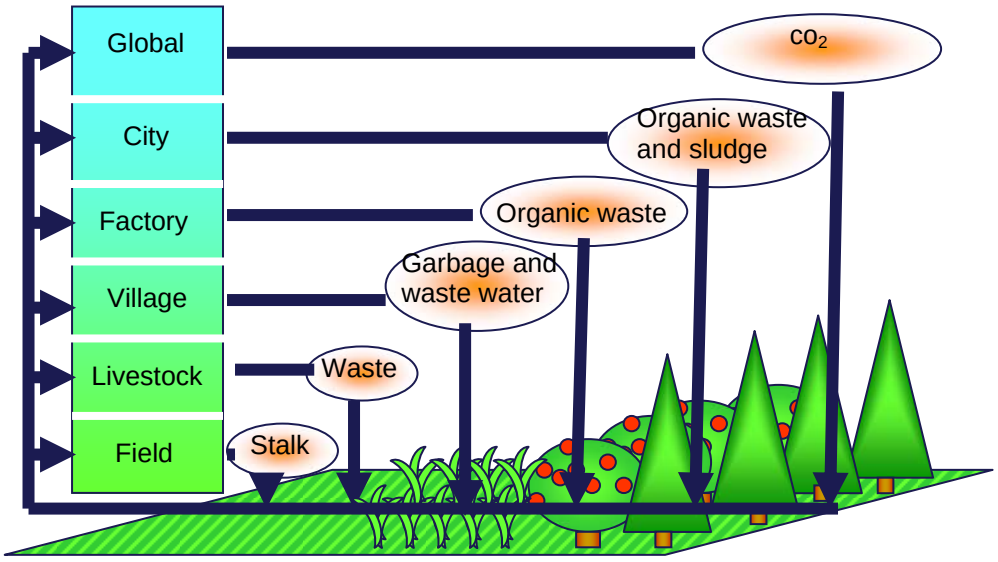

Figure 6. The recycling paths in different scales.

Straw burning is quite common in rural area. It not only causes nutrient lost, but also causes air pollution. There many mature methods can be used for straw recycling. Besides the direct return of straw through physical, chemical and biological decomposition processes such as compost, straw are also widely used as animal feed and mushroom production medium in China. Livestock waste is often used through composting and through anaerobic fermentation in a biogas tank. Biogas tanks increased quickly in the past ten years in China because of the financial subsidy provided by government. By 2007, there were about 26.5 million rural families with biogas and more than 1600 medium and large animal farms using their biogas systems. It could replace 16 million tons of standard coal. Green house – Livestock – Biogas – Crop system are widely used in North China and Livestock – Biogas – Fruit system are widely extended in South China.

Small scale waste water treatment facilities are important for livestock production and sewage water from village. Although artificial wetland technology for waste water treatment is quite mature, it has not been widely adopted in rural area because of the financial bottle neck.

Reconstruction of biodiversity relations

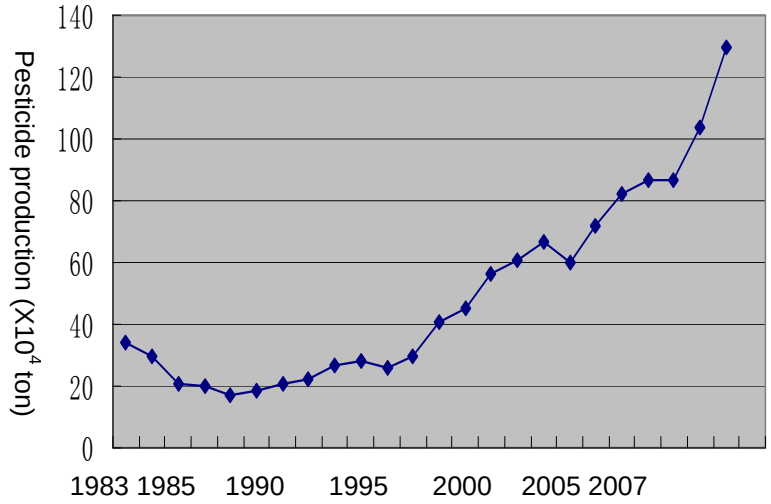

Figure7. Pesticide production in China from 1983-2007.

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 pest outbreak. The result was the increasing amount of applied pesticide and antibiotics (Fig.7). It not only causes food and environment contamination but also consumes a lot of fossil fuel and other resources. The low carbon agriculture can be achieved through the reconstruction of biodiversity relations.

(1) biodiversity landscape design

It has been proved in many studies that the orchard or crop field near “natural vegetation” has fewer pests and more natural enemies (Huang Mingdu, 2008). The “natural vegetation” includes permanent forest, wind break system, weed covered field side and irrigation channel etc. The patchy or mosaic arrangement of field crops is also good to reduce the outbreak of pests and the negative effect of Bt crop on natural enemies (Fig.8).

(2) Cropping system design

There are many good cropping systems in China, such as intercropping of short leguminous crop like soybean with tall cereal crop like corn, rubber plantation intercropping with tea, Paulownia intercropping with wheat, jujube *(Ziziphus zizyphus*).

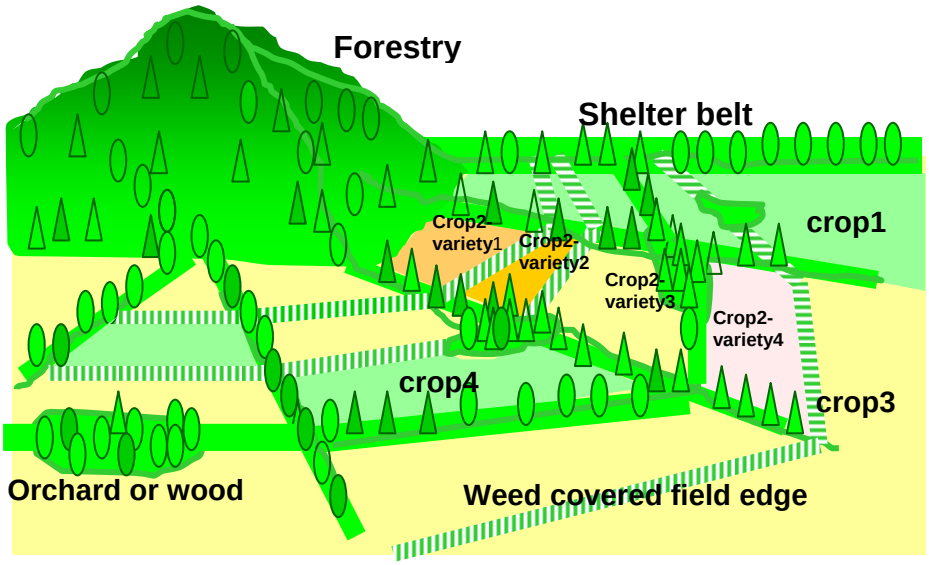

Figure 8. Biodiversity landscape design in agricultural region.

Intercropping with wheat, mix culture of grass carp, big-head carp, common carp, and silver carp in the same fish pond, paddy rice rotated with upland crops, rice resistant to rice blast disease intercropped with traditional rice species vulnerable to blast disease (Lu Liangxu, 1999; Zhu Youyong, 2007). Great progress has been made to discover the mechanisms caused mutual benefits in these systems. The niche differentiation among different species is one of the basic principles for the design of these cropping systems.

(3) Food chain design

The Rice-duck and rice-fish systems are two examples of food chain design. They can effectively control weed and certain types of pests, at the same time can reduce chemical input. The release of natural enemies for pest control such as *Chrysopa perla* which preys on cotton bollworm, ladybug which preys on aphids are examples for extend predatory food chain. And the raise of earth worm and fly larvae by animal waste and crop straw are examples to extend the detritus food chain (Li Wenhua, 2003). However, it is necessary to cut off the food chain in some cases. On the contaminated field for example, no food crop are suitable in general, only lawn, flower or wood should be grown.

(4) Antagonistic or supplementary relation design

Traditional farmers have rich experience on the relationship between plants, insects and animals. Some of the experiences have been proved scientifically and some of them are actually being used today. *Perilla frutescens* (L.) Britton is being used for repelling insects in greenhouses in Guangxi Region. Chinese wingnut (*Pterocarya stenoptera* C.DC is used to attract locusts from nearby mulberry gardens in Guangdong Province. *Ageratum conyzoides* L. is can be planted under the citric tree as a cover crop in South China, because it can provide shelter and food for predator mites which can control the harmful red mite in the citric garden and can also be used as green manure (Huang Mingdu, 2008). Research has proved that corn can attract more natural enemies to control cotton bollworm and aphid in the nearby cotton field (Wang Linxia et. al., 2005). Traditional Chinese literature recorded that sesame, hemp, green onion (Allium fistulosum), Chinese chives (Allium tuberosum), garlic (Allium sativum), or cabbage mustard (Brassica alboglabra) can repel insects on other crops (Zhou Zhaoji, 1998).

According to ancient Chinese literature, the phenomenon of allelopathy has been recognized by farmers very early. They used sesame or Perilla frutescens (L.) Britton to control weeds in newly reclaim land. Weeds can be suppressed by debris of Chinese Cinnamon (Cinnamomum cassia Presl). The spreading of bamboo through rhizome can be controlled by reed (Phragmites australis), Rhizoma Chuanxiong (Ligusticum chuanxiong Hort.), Gleditsia sinensis Lam or Mucuna sempervirens Hemsl (Zhou Zhaoji, 1998).

The resistant genes, varieties and species for environmental stress and biological stress have been identified and used in production systems for a long time (Zhu Youyong, 2007). They will continue to play a key role in future eco-agriculture in China. Many of the resistant gene resources will come from traditional varieties or wild relative species.

Motivation from moral justification

It is important to set up the evaluation system of society which can strongly show the justification on ecological and environmental responsibility of every person. Three aspects can be identified: firstly education, secondly legislation, and thirdly the evaluation standards for production and products.

(1) Education

Environmental and ecological education in China has improved significantly in our formal education system. There are many ecological and environmental contents in text books of biology, chemistry, physics and geology in primary school and middle school (Zhu Xiao-lin, Deng Xuan-chueng, 2005). However, more specific education for students in rural area on the subject of ecoagriculture is still needed to be improved (Zhang He-ping, 2002). There are courses like introduction on environmental sciences, fundamental ecology as public courses for students in many universities. The course of "agroecology" for agricultural majors is the only formal course for the principle and methods of ecoagriculture in China. However the principles of ecoagriculture have also been used in other courses like plant protection, soil and plant nutrition etc in agricultural universities.

Public media, like television, radio broadcasts and newspapers, pay more attention today to ecological and environmental issues. They also expose and criticize incidents and problems related to ecology and environment. In the newspaper network of "Farmer's Daily" (www.farmer.com.cn), "Circular Economic" provides some news and information on ecoagriculture. In CCTV, there is a channel for farmers and agriculture. A search of those programs showed that only few subjects related to ecoagriculture practices (http://space.tv.cctv.com/podcast/nongguangtiandi).

Direct training and extension for farmers should be the most important way to educate farmers. Although "the Law for Agriculture Extension" has been activated in 1993, some extension stations in rural area were involved in the promotion of pesticide, chemical fertilizer and seeds because of the commission from industries and companies. In 2006, the State Department put forward a document "On Deepening Reform and Strengthening of Agriculture Technical Extension System in County, Township and Village Level". It tried to separate the public non-profit service with profit service. There is still a lot to be done on this even today.

(2) Legislation

In the Constitution, Environmental Protection Law and Agriculture Law, principles for protection and improvement of agricultural and rural eco-environment have been proposed. The detailed regulation on the protection of air, water, forestry, fish, wild life, land and soil has been prescribed in different specific laws. The Law of the People's Republic of China on Promotion of Cleaner Production was adopted in 2002. The Circular Economy Promotion Law of People's Republic of China was activated in January, 2009. These laws provide a good framework for ecoagriculture. However, more specific and more detail regulation are still needed in China.

(3) Standards

There is the Standard for Ecological Village (2006) and the Standard for Ecological County (2007) issued by the Ministry of Environment Protection. Detailed percentages for sewage water treatment, stalk recycling, animal waste recycling, natural vegetation coverage, healthy food production which include "organic food", "green food" and "safety food", are described. The reduction of pesticides and fertilizers and the increase of soil organic matter are also proposed. However the more specific Standard for Ecoagriculture was issued by the Ministry of Agriculture in 1994. It did not cover the requirement on ecological planning, cycling index, biodiversity, environmental quality and food safety. It should be improved.

Motivation from economic benefit

A direct compensation or subsidy is an effective way to overcome the economic externalization of agricultural production activity. The subsidy for public conservation forest started from the late 1990s in China. An ecological compensation for returning the hilly cultivated area back to natural vegetation was implemented from year 2000 in northwest China. Government also subsidized farmers to build biogas tanks for the recycling of waste. However, government also subsidizes the purchasing of chemical fertilizers and pesticides by farmers since 2006, because of the rising price of these products caused by high oil prices. A clearer direction of government subsidy and stronger stimulation for ecoagriculture practices should be achieved during the policy adjustment in the near future.

The market for the discharge of pollutants is just in its experimental stage in China. The Clean Development Mechanism (CDM) created in the "Kyoto Protocol" can be widely used in agriculture, especially in forestry. By 2007, there were 1113 CDM projects approved in China. The financial support from these resources used a lot in reforestation, hydraulic power; wind mill, solar energy and biogas projects. The reduction of carbon dioxide reached 7×108t. This CDM can also be set up within China between city and rural area, or between east and west.

In general, ecoagriculture in China has gone a long way. The future development will depend upon the recognition and implementation of the key practices including agro-ecological planning, cycling agroecosystem design, and the re-establishment of biodiversity relation in agriculture. The future ecoagriculture development will also heavily rely on the favourable legislation, economic and moral environment created by our government and society.

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