Research Series on the Chinese Dream and China's Development Path

Futian Qu
Ruomei Sun
Zhongxing Guo
Fawen Yu *Editors*

Ecological Economics and Harmonious Society

SSAP

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Drawing on a large body of empirical studies done over the last two decades, the *Research Series on the Chinese Dream and China's Development Path* seeks to provide its readers with in-depth analyses of the past and present, and forecasts for the future course of China's development. Thanks to the adoption of Socialism with Chinese characteristics, and the implementation of comprehensive reform and opening, China has made tremendous achievements in areas such as political reform, economic development, and social construction, and is making great strides towards the realization of the Chinese dream of national rejuvenation. In addition to presenting a detailed account of many of these achievements, the authors also discuss what lessons other countries can learn from China's experience. This series will be an invaluable companion to every researcher who is trying to gain a deeper understanding of the development model, path and experience unique to China.

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Series Preface

Since China's reform and opening began in 1978, the country has come a long way on the path of Socialism with Chinese Characteristics, under the leadership of the Communist Party of China. Over thirty years of reform efforts and sustained spectacular economic growth have turned China into the world's second largest economy and brought many profound changes in the Chinese society. These historically significant developments have been garnering increasing attention from scholars, governments and the general public alike around the world since the 1990s, when the newest wave of China studies began to gather steam. Some of the hottest topics have included the so-called China miracle, Chinese phenomenon, Chinese experience, Chinese path and the Chinese model. Homegrown researchers have soon followed suit. Already hugely productive, this vibrant field is putting out a large number of books each year, with Social Sciences Academic Press alone having published hundreds of titles on a wide range of subjects.

Because most of these books have been written and published in Chinese, however, readership has been limited outside China – even among many who study China – for whom English is still the lingua franca. This language barrier has been an impediment to efforts by academia, business communities and policy-makers in other countries to form a thorough understanding of contemporary China, of what is distinct about China's past and present may mean not only for her future but also for the future of the world. The need to remove such an impediment is both real and urgent, and the *Research Series on the Chinese Dream and China's Development Path* is my answer to the call.

This series features some of the most notable achievements from the last 20 years by scholars in China in a variety of research topics related to reform and opening. They include both theoretical explorations and empirical studies, and cover economy, society, politics, law, culture and ecology, the six areas in which reform and opening policies have had the deepest impact and farthest-reaching consequences for the country. Authors for the series have also tried to articulate their visions of the "Chinese Dream" and how the country can realize it in these fields and beyond.

All the editors and authors for the *Research Series on the Chinese Dream and China's Development Path* are both longtime students of reform and opening and recognized authorities in their respective academic fields. Their credentials and expertise lend credibility to these books, each of which having been subject to a rigorous peer-review process for inclusion in the series. As part of the Reform and Development Program under the State Administration of Press, Publication, Radio, Film and Television of the People's Republic of China, the series is published by Springer, a Germany-based academic publisher of international repute, and distributed overseas. I am confident that it will help fill a lacuna in studies of China in the era of reform and opening.

Xie Shouguang

About the Book

The papers in this book cover issues on theory, policy, and empirical study of ecological economics. In the theory part, the book explores the discipline system of ecological economics and evaluates the progress of ecological economics research. It includes the analysis of the difference between domestic and international ecological economics study background and the difference of the ecological economists' perception, which has significant contribution to the theory of ecological economics and provides explanatory framework of ecological economics under China's situation; also, it refines ecological economics questions that needed to be studied in depth and provides the direction of future ecological economics research. In the policy part, the book includes ecological economics policies on industry development and regional development. The topics are major practical problems in Chinese ecological development, such as studies on the evolution and problems of forest and grassland industries' ecological economics policies, studies on ecological economics of ecological functional areas, studies on ecological economics of pastoral areas, and studies on ecological economics of wetland. In the empirical study part, Chinese data are utilized to examine the fundamental hypothesis of ecological economics research, such as studies on environment and resource "deficit" from international trade, studies on Kuznets curve of economic development and agricultural nonpoint source pollution (ANPSP), studies on environmental fairness under regional differences, and valuation of ecologically beneficial forest compensation mechanism and ecological system services. This part provides judgment and explanation on frontier questions in ecological economics research under Chinese background.

Acknowledgments

After a relatively short gestation period, the *Research Series on the Chinese Dream and China's Development Path* has started to bear fruits. We have, first and foremost, the books' authors and editors to thank for making this possible. And it was the hard work by many people at Social Sciences Academic Press and Springer, the two collaborating publishers, that made it a reality. We are deeply grateful to all of them.

Mr. Xie Shouguang, president of Social Sciences Academic Press (SSAP), is the mastermind behind the project. In addition to defining the key missions to be accomplished by it and setting down the basic parameters for the project's execution, as the work has unfolded, Mr. Xie has provided critical input pertaining to its every aspect and at every step of the way. Thanks to the deft coordination by Ms. Li Yanling, all the constantly moving parts of the project, especially those on the SSAP side, are securely held together, and as well synchronized as is feasible for a project of this scale. Ms. Gao Jing, unfailingly diligent and meticulous, makes sure every aspect of each Chinese manuscript meets the highest standards for both publishers, something of critical importance to all subsequent steps in the publishing process. That high quality if also at times stylistically as well as technically challenging scholarly writing in Chinese has turned into decent, readable English that readers see on these pages is largely thanks to Ms. Liang Fan, who oversees translator recruitment and translation quality control.

Ten other members of the SSAP staff have been intimately involved, primarily in the capacity of in-house editor, in the preparation of the Chinese manuscripts. It is time-consuming work that requires attention to details, and each of them has done this and is continuing to do this with superb skills. They are, in alphabetical order: Mr. Cai Jihui, Ms. Liu Xiaojun, Mr. Ren Wenwu, Ms. Shi Xiaolin, Ms. Song Yuehua, Mr. Tong Genxing, Ms. Wu Dan, Ms. Yao Dongmei, Ms. Yun Wei and Ms. Zhou Qiong. In addition, Xie Shouguang and Li Yanling have also taken part in this work.

Ms. Yun Wei is the SSAP in-house editor for the current volume.

Our appreciation is also owed to Ms. Li Yan, Mr. Chai Ning, Ms. Wang Lei and Ms. Xu Yi from Springer's Beijing Representative Office. Their strong support for the SSAP team in various aspects of the project helped to make the latter's work that much easier than it would have otherwise been.

We thank Ms. Wang Xiao'e for translating this book and Ms. Jiang Lin for her work as the polisher. The translation and draft polish process benefited greatly from the consistent and professional coordination service by Beijing Zhong Huiyan Information Services Co., Ltd. We thank everyone involved for their hard work.

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Assessment of and Outlook for the Study of Ecological Economics

Li Zhou

1.1 How to Understand the Concept of Ecological Civilization Introduced During the 17th CPC National Congress

One view is that this concept is a milestone event that marks China's entry into a new era of ecological civilization. Encouraging as it sounds, this view is not accurate. From the process in which the CPC outlines the system of civilizations, we can say that the CPC advocates this concept in order to improve the system of civilizations rather than make a choice to usher China into a new era of ecological civilization.

In the long run, the academic community divided the patterns of civilization by the dominant modes of material production, such as agricultural civilization and industrial civilization.

In September of 1979, the 4th Plenary Session of the 11th CPC National Congress adopted the speech delivered by Comrade Ye Jianying on behalf of the CPC Central Committee, the Standing Committee of the National People's Congress and the State Council at the celebration of the 30th anniversary of the founding of the People's Republic of China. According to the speech, the four modernizations China advocated for refer to the achievement of modernization in four major aspects, but they are not limited to the four aspects. In addition to reforming and improving the socialist economic system, we should reform and improve the socialist political system, develop an advanced socialist democratic system and a well-established legal system. While building an advanced material civilization, we should also improve education, science, culture and health care for

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the entire nation, uphold lofty revolutionary ideals and a code of morality, build a colorful life and construct an advanced socialist spiritual civilization. These are all important objectives of socialist modernization, and are also prerequisites for achieving the four modernizations. This statement specifies the concept of socialist spiritual civilization, and summarizes the content of the socialist spiritual civilization, i.e. education, science, culture and revolutionary ideals, revolutionary morality and cultural life. It also stipulates that socialism should be built into two civilizations – material and spiritual civilizations, each emphasizing that a socialist spiritual civilization is an important goal of socialist modernization and an important requirement for achieving four modernizations. On July 13 of 1983, Comrade Hu Qiaomu said at the national conference on publicity work that the proposition of spiritual civilization represents an important development of Marxism and Mao Zedong thought.

The 16th CPC National Congress specified that to build a moderately prosperous society in all aspects and create a new situation in building socialism with Chinese characteristics, we should, under the strong leadership of the Communist Party of China, develop a socialist market economy, socialist democracy and socialist culture, constantly boost the coordinated development of socialist material civilization, political civilization and spiritual civilization so as to advance the great rejuvenation of the Chinese nation.

The decision adopted by the 6th Plenary Session of the 16th CPC National Congress on building a harmonious socialist society further pointed out that we should promote the coordinated development of social, economic, political and cultural construction. That is to say, to bring about comprehensive development, we need to achieve the integrated advancement of economic, political, cultural and social development, with economic development as the center.

Following this approach, it's not hard for us to understand that the concept of ecological civilization proposed by the 17th CPC National Congress actually expands the integration of social, economic, political and cultural development into the integration of social, economic, political, cultural and ecological development.

1.2 An Evaluation of Differences in the Study of Ecological Economics

1.2.1 Differences in the Background Study of Ecological Economics at Home and Abroad

Both Kenneth E. Boulding and Herman E. Daly proposed the concept of ecologic economy in response to the ecological degradation under the state of relative surplus (or excessive consumption) rather than the state of absolute shortage (or inadequate basic consumption). As ecological capacity fell short of the unlimited demand for economic growth, they proposed the theory of steady-state economy and zero growth. When putting forward the concept of ecologic economy in the 1980s, Chinese scholars targeted the ecological degradation under the state of absolute shortage (of inadequate basic consumption) rather than the state of relative surplus (or excessive consumption). At that time, China's economic growth failed to meet the basic needs of all people, and China still lacked the critical conditions outlined by scholars in developed countries for the steady-state economy and zero growth state. This is the first difference in the starting point for the study of ecologic economy at home and abroad.

In developed countries, the concept of ecological economics was proposed for negative externalities caused by industrial pollution and agricultural pollution (fertilizers and pesticides). In contrast, the proposition of ecological economics in China mainly targeted negative externalities exposed in primary resource exploitation activities, including deforestation, grass destruction and reclamation of land from lakes. This is the second difference in the starting point for the study of ecologic economy at home and abroad.

In developed countries, the concept of ecological economics mainly aimed at market malfunction. But in China, the concept of ecological economics mainly targeted government failure and policy failure. To put it more straightforwardly, it focused on the severe consequences of policies that put undue emphasis on grain and low costs. At that time, producers didn't yield super profits because of cost externalization, and there were no conflicts between selfishness and interest in the welfare of others. This is the third difference in the starting point for study of ecologic economy at home and abroad (Table 1.1).

At the stage when conventional economic growth fails to meet the increasing basic needs of a rapidly growing population, the main approach to address is to exploit natural resources and convert the stock of natural wealth into the flow (means of livelihood) and stock (means of production) of social wealth. The ecological degradation caused by improper resource exploitation at this stage can be called the ecological degradation at the poverty stage. After this stage, domestic and external demands are expanded to spur consumption and production, and the

Table 1.1 Differences in ecological degradation at different stages of development

	Under-developed stage	After under-developed stage
What's in common	Ecological degradation	Ecological degradation
Problems	Insufficient growth and universal shortage	Excessive growth and universal over-consumption
	Improper development in agriculture and resource mining	Industrial and agricultural pollution
	Government failure	Market failure
Basic reasons	Increase in basic supplies	Spur in demand for luxuries
	Acceleration in resource development	Improvement in resource processing

conversion of the stock of natural wealth into the flow (means of livelihood) and stock (means of production) of social wealth is scaled up. The ecological degradation caused by the failure of the limited ecologic capacity to meet the unlimited ambition for economic growth can be called the ecological degradation at the developed stage. My basic assumption is that the more developed the economy is, the more prominent the role that ecological economics plays. The rationale is that when economic poverty and ecological degradation intertwine, the size of the population that puts the concept of ecology first is quite limited. After this stage, the size of this population will keep growing as a result of social and economic development. This is also the major reason why ecological economics is recognized by more and more people.

1.2.2 Cognitive Differences Among Ecological Economists

Ecological economists fall into different schools. Radical and moderate ecological economists vary greatly in their perception of ecological economics. In the eyes of radical ecological economists, the existing economic theories can't be used to address the problems of ecologic economy, so the theory of ecological economics is designed to take the place of all the existing economic theories. For instance, Lester Brown thinks that ecological economics is proposed to facilitate the substitution of economy-centrism by eco-centrism, which is as significant as the substitution of the geocentric model by heliocentrism. These scholars stress eco-centrism, emphasize biological equity, and devote immense passion to winning the social recognition of their views. They adopt economic philosophies and carry out standardized research. Some influential Chinese ecological economists also think that ecological economics ushers in the age of ecological civilization. Nevertheless, moderate ecological economists hold that the problems of ecologic economy accumulated in reality have come to a point where they must be addressed, and that ecological economics will be constantly developed in solving these problems and will thus play an increasingly important role in the system of economics. Bearing in mind that ecological economics is a branch of the system of economics, they always place people first, take the economy as the center and firmly believe that the study of ecological economics will contribute significantly to making a better real world. They mainly adopt empirical analysis in their work. Between the two types of economists are ecological economists who strive to realize self-fulfillment. These economists neither have specific academic ideas and theories, nor focus on solving the problems of ecologic economy in reality. Instead, they mainly strive to fully realize their own values (Table 1.2).

Table 1.2 Differences between ecological economists

	Moderate ecological economists	Ecological economists striving for self-fulfillment	Radical ecological economists
Judgment	Problems in reality must be addressed	Ecological Economics has bright prospects	The existing economic theories must be replaced
Idea	People first (People are equal)	Self first (they themselves are the most important)	Species first (all species are equal)
Focus	Economy-centrism	Uncertain	Eco-centrism
Goal	To make a better real world	To bring into full play their own abilities	To get their ideas widely recognized
Methodology	Empirical research	Uncertain	Normative research

1.2.3 Cognitive Differences Among Economists of Closely Related Disciplines

In reality, not only ecological economists but also economists of closely related disciplines differ in their cognition. Interestingly, some scholars are reluctant to clarify the relations between closely related disciplines by defining disciplinary boundaries. Instead, they opt to define disciplines with the statements of scholars. For instance, some of them think that Kenneth E. Boulding was an ecological economist and his statements were on ecological economics because he proposed the concept of ecologic economy. Others argue that Boulding expounded many environmental problems, so he was an environmental economist, and his discourses were on environmental economics. If the academic debate stays on this level, it will neither reach any consensus nor facilitate academic progress or harmony among scholars of different disciplines. The fact that people differ in their understanding of the disciplinary categorization of the same paper or the same book proves the existence of unclearly-defined boundaries between different disciplines.

As environmental economics emerged earlier than ecological economics, some scholars on the environment regard the latter as a branch of environmental economics. For instance, in some present literature, the book *Ecological Economics*, compiled by Japanese scholar Sakamoto Fujiyoshi and published in 1976, is regarded as the world's first book on ecological economics. But in fact, the subtitle of this book is *Primary Introduction to Environmental Science* (1976). In the book *Introduction to Environmental Science* (3rd Edition), by He Qiang, Jing Wenyong[1] and Wang Yuting of Tsinghua University and published by Tsinghua University Press, ecological economics is also categorized as one of the building blocks of environmental economics (Fig. 1.1).

[1] Jing Wenyong, dean of Environmental Engineering at Tsinghua University between 1984 and 1994, who concurrently served as head of the Environmental Engineering Institute of Tsinghua University between 1987 and 1994, and head of Tsinghua Environmental Engineering Design & Research Institute between 1993 and 1996. In 1990, he was a member of the first Steering Committee for Environmental Engineering of the State Education Commission.

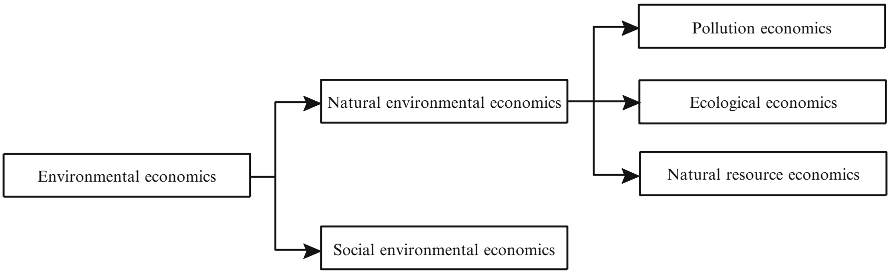

Fig. 1.1 Discipline system of environmental economics shaped by environmental deviations

Several years ago, the Ford Foundation Beijing Office offered to fund the Chinese Academy of Social Sciences to build up its research capacity in ecological economics. Moreover, it suggested naming the discipline Resources and Environmental Economics so that the Ford Foundation head office could approve this project. This can be interpreted as the following: first, the boundary between ecological economics and environmental resource economics is not clearly defined, resulting in interchangeability between the two disciplines; second, comparatively speaking, the boundaries surrounding ecological economics are not as clear as those surrounding environmental economics or resource economics; third, ecological economics is not as well socially recognized as environmental economics or resource economics.

Why would this happen? The late birth of ecological economics is just a superficial reason. There are three more pertinent reasons. First, pioneers of ecological economics in China focused on the resolution of ecological problems rather than the construction of the discipline. In other words, at that time most people thought that it was high time to study ecological problems, rather than speculate that the existing economics didn't work. Second, some ecological economists took pride in "firing the first shot" instead of taking delight in studying assiduously and perseveringly. Third, researchers preferred to pioneer new realms but ignored condensing connotations and staying on the rails. Consequently, economics has continually improved version after version while ecological economics has independently expanded in book after book.

1.3 Rationale for Ecological Economics

The difference in cognition of some relations in reality among so many highly intelligent scholars is definitely related to the crossing of boundaries among related disciplines. The crossing we refer to here is not the crossing between ecology and economics, but the crossing between ecological economics and other schools of economics. What is good about unclear discipline boundaries is that things can be done without constraints, i.e. we can do everything or nothing. However, boundaries are the foundations of disciplines. Without clear boundaries, research goals

Table 1.3 Relations between ecological economics and several relevant economic disciplines

	Mainstream economics	Resource economics	Environmental economics	Ecological economics
Basic problem	Optimum resource allocation	Sustainable resource utilization	Internalized external effects	Inefficient growth
Basic methods	Marginal analysis	Fluctuation balance and substitution balance	Taxation-compensation	Analysis of social optimization
Key measures	Competition	Improvement of human capital	Competition	Cultivation of collective rationality
Regulating means	Financial and monetary	Innovation	Total control and trading	Scaling up of unity between self-interest and interest in the welfare of others

and tasks cannot be very specific, research methods cannot be very distinctive and what is done do not receive wide recognition by outsiders. With this in view, we will start from the position of ecological economics before diving into the boundaries of ecological economics (Table 1.3).

The basic problem of mainstream economics is how to realize optimum resource allocation. The basic theory behind it is as follows: under the market mechanism and in an environment where competition and information are adequate, vendors can leverage marginal analysis to find the scheme to optimize resource allocation and the specific method to put the scheme into practice. The basic function of the government is to protect legitimate property rights (including intellectual property rights), safeguard fair competition and provide public goods. Supplementary means include regulating income distribution (secondary distribution with an emphasis on social equity)[2] and promoting the growth of charitable organizations (the third distribution with an emphasis on social responsibilities).

The basic problem of resource economics is how to realize the sustainable utilization of open natural resources (in a competitive but not exclusive manner). There are five specific measures. First, determine the amount for sustainable utilization. For instance, the amount of water withdrawal can be determined according to the exploitable yield, deforestation according to wood increments, livestock capacity according to forage yields of grassland, and catch size according to the yield of fish. Second, issue permits, such as permits for water withdrawal, deforestation, grazing and catching to grant resource use rights to specific communities (or groups).[3] Third, introduce appropriate institutional arrangements, including inducible institutional arrangements and compulsory institutional

[2] Secondary distribution includes poverty relief, emergency relief, progressive income tax (intra-generation equity) and inheritance tax (inter-generation equity), etc.

[3] The openness of natural resources is often for the inside of certain communities. If the use rights of open natural resources are granted to businesses and farmers, such resources are no longer open natural resources.

arrangements. Examples of the former include ecological compensation systems for forests, grasslands and fisheries. Examples of the latter include systems banning deforestation, grazing and catching. Fourth, narrow the scale of openness and guide community cooperation. Fifth, promote technological innovation.

The basic problem of environmental economics is how to internalize external costs (effects). There are three basic measures. First, internalize external costs through taxation. Second, internalize external benefits through compensation. Third, carry out emissions trading on the premise of controlling gross emissions. This will, on the one hand, fully leverage the self-decontamination capacity of the ecosystem, and on the other hand render emission rights rare resources which will become demanded and priceable. Emissions trading is conducive to the reduction of pollution control costs and the diversion of emissions rights to more efficient enterprises or industries. If governments and environmental organizations no longer sell the emissions rights they purchase, the total amount of pollutants that can be emitted or discharged will be gradually lowered and the environmental quality improved.

The basic problem of environmental economics is how to avoid inefficient economic growth, such as economic growth correlated to the induction of disease of affluence. According to the concept of ecological economics, first, growth rates are not decided by demands backed up by paying abilities, but by effective demands. Second, effective demands include not only the demands of the present generation, but also the demands of successive generations. Third, effective demands incorporate not only people's demands, but also natural demands. The organic unity between self-interest and interest in the welfare of others constitutes the basic approach to addressing ineffective economic growth. But the scope and extent of that ineffective economic growth which can be addressed depends on the scale of unity between self-interest and interest in the welfare of others. The basic measure of ecological economics is to leverage collective rationality for social optimization and unity between self-interest and interest in the welfare of others.

Self-interest is a right, while interest in the welfare of others interest in the welfare of others is a responsibility. The symmetry between a right and a responsibility is also the symmetry between interest in oneself and interest in others interest in the welfare of others. The two interest in the welfare of others indeed complement each other, just like the two sides of a coin. However, the scale of unity between self-interest and interest in the welfare of others increases with the development of human society and the expansion of rule recognition. At the birth of human beings, self-interest and interest in the welfare of others were united in a very small scale which was only confined to the inside of a clan and was not much different from that of animals. In case of shortage crisis, wealth was generally re-distributed by violent means. As violent conflicts were often correlated to wealth loss, they resulted in negative-sum games or at most zero-sum games. Wealth re-distribution through clashes was not conducive to the formation of stable expectations among people, the accumulation of social wealth, or the promotion of human advancement. After years of vicissitudes, people finally came up with a way to get the results of positive-sum games, i.e. by restraining their own behavior as per commonly accepted rules. The so-called positive-sum game refers to Pareto improvement or Kaldor improvement. Pareto improvement means that at least one person benefits without anyone else sustaining a loss. In contrast, Kaldor improvement means that in the improvement process where some people benefit at the expense of others, beneficiaries provide compensation for maleficiaries so that at least one person can benefit without anyone sustaining a loss. Obviously, the attainment of such results objectively requires collective rationality and altruistic perspectives. What's gratifying is that the scale of unity between self-interest and interest in the welfare of others will keep expanding as a result of the constant improvement in commonly recognized rules.

Some may say that such an assertion is miles from reality. But in fact it is not. If people haven't pursued interest in the welfare of others, why has philanthropy boomed and why are there more and more volunteer efforts? If people rejected interest in the welfare of others, why has the behavior of Fan Meizhong (a high school teacher who infamously ran out of his classroom during the Wenchuan earthquake, leaving students behind) been condemned by the public?

Why has the small-scale collective rationality, such as the recognition of villages and village rules by villagers, been expanded to large-scale collective rationality, like the recognition of national laws and regulations by all citizens? Why has regional cooperation (such as the EU and APEC) been expanded into global initiatives (such as the UN and WTO)? The main reason is that ineffective economic growth can only be avoided through cooperation, and apparent and potential opportunities for win-win progress can only be obtained through cooperation.

1.4 Ecological Economic Problems in Urgent Need of Further Study

1.4.1 Realization of Collective Rationality and Social Optimization

The realization of collective rationality and social optimization can be approached from three dimensions. First, protect ecosystem capacity. To put it simply, people's understanding of protecting ecosystem capacity goes through three stages. The first stage emphasizes the potential value of unknown species. The second stage stresses the guiding role that the internal mechanism of an ecosystem plays in improving the production of a system and then increasing the production efficiency. The third stage underlines the indispensability of biodiversity. Second, expand the limited supply. Third, regulate the unlimited demand.

To expand the limited supply, we need to establish relations between the earth and the outer space, such as utilization of solar power and space breeding. Indeed, it is not practically viable to harness solar power at present. However, how to increase the energy levels of solar power through photovoltaic, photo-magnetic and photothermal conversion so that it can replace fossil energy is an extremely important scientific issue. The earlier and the more we pay attention to it, the more likely that it will become practically feasible. In a word, from the perspective of ecological economics, the establishment of material and energy exchange between the earth and the outer space is crucial to the sustainable development of human beings. Therefore, the fundamental problem is how to secure energy that can replace fossil energy as soon as possible, rather than find out how many more years existing energies can be used.

To regulate the unlimited supply, we need to put in place a more effective institutional mechanism. For instance, build a system of primary, secondary and tertiary methods for equitable income distribution; replace the family security system with a social security system for a decline in total population; reduce total emissions by controlling total pollution, trading emissions rights and implementing a clean development mechanism; and substitute a science-based economy for a resource-based economy through technological and institutional innovation. All these four aspects are realistic proposals. For example, the Gini coefficient, total population and total pollution are on the decline in some developed countries where the total factor of productivity is well over 80 %. Although the number of such places is still quite small, there is a reason to believe that there will be more and more thanks to social and economic development.

1.4.2 Ecosystem Service Value

The study of ecosystem service value has a long history. Costanza and his peers were the first to estimate global ecosystem service value. The annual value of global ecosystem service is estimated to be US16-54 trillion dollars, with the average being US 33 trillion, representing 1.8 times the gross national product (GNP) around the world which is valued at US 18 trillion (Costanza, etc. 1997). This work plays an important warning role, but fails to answer the question of how to optimize the utilization of ecosystem service value. To be specific, there are three questions to be answered. The first is how to integrate ecosystem service value and aggregate social product to change the fact that they cannot currently be added. This is fundamental to optimize the utilization of ecological assets. The second is how to improve the method of quantifying ecological value and how to define the quantification unit so as to increase the accuracy of ecosystem service value. The third is how to study the correlation between ecosystem service value and the value of ecological assets at the micro level and assess the quality of various ecological assets.

1.4.3 Energy Theory

The energy theory is proposed in an attempt to replace subjective value indicators with objective ones. This is obviously a good idea. However, when we think it over, we see problems coming one after another. First, except for agriculture, all other non-agricultural production processes consume energy. If the energy theory is tenable, we can conclude that it is better to produce less than more and better to produce none than less. Agricultural products shouldn't be processed, because energy won't increase in the process. Instead, energy will be consumed. Second, let's put aside whether the energy of materials in different categories is comparable or addable. Even solar power and oil of the same energy amount are not comparable or interchangeable because of different energy levels. Third, economics simplifies the relations between all things into inter-person (or inter-business) relations. This is also a good idea. But according to the energy theory, the study of economics is clearly complicated and the amount of required information is significantly increased. This shows that to transform the energy theory from an idea into a practical method and tool, these problems must be effectively addressed.

1.5 Conclusion

In the last thirty years, much progress has been made in the study of ecological economics in China. But there still remain some problems worth studying, which present a rich ore to be exploited. To participate in the study of ecological economics and make socially recognized achievements requires the will to persist and follow local, normalized and international rules. Relevant references in these years show that the younger the authors are, the more advanced methodologies they employ and the more standardized their argumentation is. For this reason, we believe that young ecological economists are quite promising, and that the discipline of ecological economics has a bright future.

Chapter 2
The Definition, Scope and Principles of Ecological Economics

Shen Manhong

2.1 The Definition of Ecological Economics

2.1.1 Ecological Economic Issues

To define ecological economics, we must first find out what ecological economic issues are. By definition, ecological economic issues represent the confrontation between ecological non-recycling and reverse economic ecologicalization, and between ecology and economy.

2.1.1.1 Ecological Non-recycling

For a long time, people categorized goods into economic goods and free goods. Economic goods refer to goods that can only be used on a compensatory basis, such as clothes and food. Free goods refer to goods that people needn't pay to use, such as air or water. The reason why economic goods can only be used on a compensatory basis is that they are assumed to be scarce resources. The "fee" paid for them is the symbol used to measure the scarcity of the goods. Free goods are free to use because they are assumed to be inexhaustible.

Now it seems that the categorization of economic goods and free goods is no longer tenable, as there are no absolutely free goods. Instead, some free goods are becoming economic goods. People are now used to paying for clean water. Clean air is becoming an increasingly scarce resource for which consumers must pay. People in urban areas pay to enjoy a few breaths of fresh air in "oxygen bars."

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Therefore, the long-standing view of "ecology" as "non-resource" is now hard to maintain.

The treatment of ecological resources as free goods is a sign of ecological non-recycling. A more prevailing problem is the failure to make the prices of ecological resources fully reflect their scarcity. A too-low water price has resulted in the overuse and waste of water resources. A timber price that doesn't reflect timber's ecological value has led to exploitative logging of forest resources. Moreover, the mining of mineral resources regardless of ecological costs has transformed mines from "cradle" to "grave."

2.1.1.2 Economic Development That Violate Laws of Ecology

If "men" are used to represent human society and "heaven" used to represent "nature," i.e. the ecosystem, the evolution of relations between human society and the ecosystem can be roughly divided into the following four stages:

1. Prehistoric civilization. This was the stage in which "men lost out to heaven." As the capabilities of men to learn about and adapt to nature were quite limited at this stage, while nature was quite capricious and rapidly changing, human society could easily be devastated by nature.
2. Agricultural civilization. This stage was characterized by "unity between men and heaven." At this stage, as a result of cognitive advancement and the use of working tools, men were more adaptable to nature. A mode of production which combined labor and land maintained the balance between men and nature. Consequently, human society didn't do great harm to nature.
3. Industrial civilization. This stage was characterized by "men's triumph over heaven." The advance of science and technology and the invention of machines significantly enhanced the capabilities of men to deal with nature. As a result, nature was cognitively outmatched by men who were the masters of nature and nature which was the slave of men.
4. Ecological civilization. This stage is characterized by "harmony between heaven and men."In terms of their view of the world, through a spiraling series of logical negations, men gradually realize that they are just a part of nature, and that harmony between human society and nature must be rebuilt.

Defiance against ecological principles of economic development began with agricultural civilization and reached its peak during industrial civilization. The dominant development view of industrial civilization stage was generally a mechanical development view which simply placed men in opposition to nature rather than in harmonious unity. Mechanical development views at this stage were represented by the impulse to "rein in nature and become the master of nature" and the idea "that the negation of nature constitutes the road to happiness." At this stage these mechanical development views began to prevail around the world, encouraging men to transform and conquer nature. Although men made remarkable economic achievements by following this development pattern, problems arose, including a serious population explosion, ecological disasters, resource exhaustion and an environmental crisis.

By reflecting on these mechanical development views, we find at least three obvious flaws:

First, they ignore the fact that men are part of nature by emphasizing that men are the masters of nature, with men simply placed in opposition to nature rather than in harmonious unity. This is a fundamental issue concerning how men perceive nature and society, i.e. an issue of world view. This error in world view will result in a wrong development view.

Second, they ignore the finitude of natural resources, dismissing the basic law of thermodynamics. They assume that natural resources which economic growth relies on are inexhaustible, and therefore their exploitation is subject to no restrictions. But, in fact, "we have only one earth." Mechanical development views have a distorted recognition of resources.

Third, they ignore the fact that the ecological environmental capacity is limited, so they violate the fundamental law that economic development should be based on a virtuous circle of ecological environment. They assume that the self-cleansing capacity of the natural environment is unlimited, and that the capacity of the natural environment to absorb waste from human activity and life will never decline, such that no restriction need apply to its utilization. But in fact, environmental capacity is limited. This shows that mechanical development views is based on a fundamentally misleading perception of the environment.

2.1.1.3 A Confrontation Between Ecology and Economy

There are four possible combinations between "good" ecological protection, "bad" ecological protection, "rapid" economic growth and "slow" economic growth.

Combination 1 (good and rapid) constitutes a balanced objective that conforms to social needs. This state requires a positive interaction rather than a confrontation between ecological protection and economic growth. This is the goal pursued by ecological civilization.

Combination 2 (good and slow) is not a balanced objective that fits social needs. In this state, the ecology is well protected, but the economy remains stagnant. This combination is similar to the "Zero Growth Mode" advocated by environmental protectionism, which stresses ecological protection but ignores economic development. However, people's basic needs can hardly be satisfied without economic growth, which would further render it difficult to sustain ecological protection.

Combination 3 (bad and rapid) is not a balanced objective that matches social needs, either. This is a mode commonly adopted by developed countries in their industrialization processes, and it is also a realistic problem China encountered in its process of industrialization. This combination realizes the goal of high yield at the expenses of large investment, high consumption and high emissions, which results in deteriorating ecological conditions.

Combination 4 (bad and slow) is not a balanced objective that meets social demands. This state is in ecological poverty mode, i.e. the poorer people get, the more they rely on natural resources; the more they rely on natural resources, the more destructive they are to the ecology; and the more destructive they are to the ecology, the poorer they become.

Up to now, the mode which attains sound ecological protection as well as good and rapid economic growth has been quite rare. What is more common are good but slow, rapid but bad, or bad and slow modes. As such, the advance of ecological economics is required, which calls for greater effort by ecological economists.

2.1.2 The Definition of Ecological Economics

We think that, based on an analysis of ecological economic issues, ecological economics is an economic science that studies and solves ecological economic issues, dives into the operating laws of the ecological economic system, and aims to achieve coordinated development between the ecological transformation of the economy and the economic utilization of ecology, and between the ecosystem and the economic system.

This definition has several characteristics, and they are as follows:

First, ecological economics is a social science and an economic science in social sciences. Although it is based on laws of nature, especially laws of ecology, ecological economics explores these laws from an economic perspective.

Second, ecological economics is problem-oriented, i.e. its study starts from ecological economic problems. Ecological economics is not a pure theoretical economics which goes from theory to theory, but a practical theoretical economics that combines both theory and practice, moves up from practice to theories and then uses theories to guide practice.

Third, ecological economics must sum up some ecological economic laws in core fields. If there is no law to follow, the existence of ecological economics would become meaningless.

Fourth, ecological economics seeks to coordinate development between ecological modernization of the economy and the economic utilization of the ecology, and between the ecosystem and the economic system.

Ecological modernization requires all economic activities to follow both economic and ecological laws so that they will not do any harm to the ecological environment. The transformation from a "black economy" and a "white economy" to a "green economy" is the process of ecological modernization.

The economic utilization of the ecology requires that we study not only the ecological value but also the economic value of all things in nature, and that we should not treat them as free goods which can be used without payment, but as precious ecological resources. The view that "clear waters and green mountains equal gold hills and silver hills" actually refers to ecological economization. In the context of ecological economization, to protect the ecology is to protect productivity.

The positive interaction between the ecosystem and the economic system requires that the ecosystem and the economic system don't conflict with each other but develop together in a coordinated manner and coexist in harmony. A harmonious society includes intra-generation harmony, inter-generation harmony and the harmony between men and nature.

2.2 The Scope of Ecological Economics

Scope is a basic concept that reflects the essential attributes and universal relations of things, a logical form of rational human thinking, and a development indicator of human theoretical thinking in a certain period of history. The word scope generally refers to a supreme concept. When used to name a particular type of objects, it often refers to a discipline or a field, such as science and rationality. Normally, a scope concept covers the largest range of objects, and can be used to address the highest level of class in a systematic way.

All specific sciences have their own scopes. For instance, combination and decomposition fall into the scope of chemistry. Commodity value, abstract labor and concrete labor fall into the scope of political economics. Demand, supply, cost and benefit fall into the scope of modern economics, which consists of microeconomics and macroeconomics, also known as the four-word policy of economics. An important prerequisite for new institutional economics to become an independent branch of economics came when Ronald Harry Coase proposed the concept of transaction costs. In a similar manner, ecological economics could become an independent branch of economics because it has its own important scope.

Professor Liu Sihua probed the scope of ecological economics back in 1985. "Ecological balance and economic balance, and the dialectic unity between them constitute the ecological economic balance. Ecological structure, economic structure and the dialectical unity between them make up the ecological economic structure. Ecological objectives, economic objectives and the dialectical unity between them constitute ecological economic objectives. All these represent the essential scope and concepts of ecological economics," [1]he noted. These indeed form an important scope of ecological economics. But they fail to constitute the complete scope of ecological economics. In the book *Researches on Some Issues in Theoretical Ecological economics*, published in 1989, Professor Liu further unveiled and dived into the basic concepts and essential scope of ecological economics, including the ecological economic system, ecological economic relations, ecological economic structure, ecological economic balance, ecological

[1] Liu Sihua, Collected Works of Liu Sihua on Sustainable Economy, China Financial & Economic Publishing House, June of 2007.

economic benefits and ecological economic objectives. This pushed the exploration of the scope of ecological economics a major step forward.

Based on the views of previous studies, the essential scope of ecological economics includes the ecological economic system, ecological economic industry, ecological economic consumption, ecological economic benefits, ecological economic institutions, etc.

2.2.1 The Ecological Economic System

The ecological economic system refers to a composite system in which the ecosystem and economic system intertwine, interact and impose mutual constraint on one another. It is a structure that results from the combination of technical intermediaries and human labor for material circulation, energy conversion, value increment and information transfer. This system is highly dependent in that each economic process is based on the ecosystem and can't exist independently of the ecosystem.

To understand the ecological economic system, we must first learn about the ecosystem. An ecosystem is a community of living organisms (including animals, plants and microorganisms) that exists in conjunction with nonliving components (things such as air, water and soil). It is the combination of a life system and an environmental system in a specific space.

To understand the ecological economic system, we must also learn about the economic system. An economic system is a combination of productive forces and productive relations in a specific geographical and social environment. It is an integrated community comprised of production, exchange, allocation and consumption in the process of social reproduction.

With regard to the view that the ecological economic system is a composite system consisting of an ecosystem and economic system, there are three different perceptions. Some think that the ecosystem is a subsystem of the economic system and subordinate to the economic system. Some think that the ecological economic system is the part where the economic system and the ecosystem overlap. Others think that the economic system is a subsystem of the ecosystem, and that the economic system must carry out activities within the range allowed by the ecosystem. As people's understanding of the ecological economic system deepens, their perceptions become increasingly close to the third view.

2.2.2 The Ecological Economic Industry

The ecological economic industry is a composite ecosystem in which industrial development is based on the tolerance of the ecological environment. Economic reproduction is scaled up, while natural reproduction synchronizes economic development and ecological protection, eventually facilitating the virtuous cycle of economy, society and nature.

Ecological economic industry contains several different industries. According to the classification of three major industries, ecological economic industry can be divided into ecological agriculture, the ecological industry and the ecological service industry. Ecological agriculture can be divided into narrow-sense ecological farming, ecological forestry, ecological animal husbandry and ecological fishery. Ecological industry can be divided into ecological manufacturing, ecological chemical industry and ecological processing. The ecological service industry can be divided into ecological tourism, ecological logistics, ecological finance and the ecological information industry.

Ecological agriculture is an agricultural development pattern which follows ecological and ecological economic laws, applies system engineering methodologies and modern technologies, and carries out intensive management while protecting and improving the agricultural ecological environment. It is a composite system of agricultural ecological economy which comprehensively integrates the agricultural ecosystem and agricultural economy for maximum ecological economic benefits. It is also a mega-agriculture industry which combines farming, forestry, animal husbandry, sideline productions and fisheries, and a modern agriculture that integrates agricultural production, processing, and marketing to accommodate the development of market economy.

Ecological industry is an industry that establishes an ecological industrial chain of producers, consumers and decomposers which is equivalent to an ecosystem because it simulates ecosystem functions for low input, low consumption, low pollution or no pollution, and the coordination between industrial development and ecological environment. Ecologicalization of industrial structures refers to the process in which the structure of industrial systems is planned as an industrial ecological chain comprised of resource production, processing and decomposition. The resource production sector is equivalent to the primary producer in an ecosystem, which is mainly responsible for producing renewable and non-renewable resources, developing and utilizing non-renewable resources, striving for the substitution of renewable resources with non-renewable resources, and providing primary raw materials and energy for industrial production. The processing sector is equivalent to the consumer in an ecosystem, which strives for a waste- and pollution-free production process, and processes the primary resources provided by the resource production sector into industrial products to meet the need of production and the life of men. The decomposition sector is responsible for recycling or properly disposing of various byproducts, or transforming them into new industrial products.

The ecological service industry refers to the sector which fully embodies ecological concepts in service facilities, service means and service channels, does no harm to the ecological environment in the service process, and establishes and intensifies an ecological awareness among consumers when they receive service.

2.2.3 Ecological Economic Consumption

Ecological economic consumption is also known as ecological consumption or sometimes green consumption. While having much in common, the concepts of ecological consumption and green consumption have many differences. Green consumption is a type of consumption that aims to be green and to promote nature, harmony and health. But such consumption pays more attention to how to meet the consumption demands of the current generation for harmony and health. In contrast, ecological consumption, while laying stress on being green and promoting nature, harmony and health, attaches more importance to how to meet the consumption demands of future generations.

Therefore, ecological consumption is a type of ecologically informed consumption. It refers to consumption behavior that conforms to the development of both material production and ecological production, which is beneficial to the improvement of people's health, the satisfaction of people's consumption demands, and the protection of the ecological environment. Generally speaking, ecological consumption has a wider denotation and includes all the sectors and stages of green consumption. For its part, green consumption is part of the denotation of ecological consumption and a basic part of ecological consumption.

When people's consumption behavior has the function of protecting the ecology, it is a type of ecological consumption. Ecological consumption is embodied in the following aspects: the consumables themselves are ecological, i.e. the green and environmentally-friendly commodities; the sources of consumables are ecological, i.e. the raw materials, production technologies, processes and their relations with the environment are all ecological; the consumption process is ecological, i.e. the use of consumables does not do harm to the work and life of other social members and the surroundings; the consumption result is ecological, i.e. after the consumables are used, no excessive garbage, noise, waste water, waste gas or any other consumption remnants are generated which can be disposed of within a short time and will cause a pressure and destruction to the environment.

2.2.4 Ecological Economic Benefit (Efficiency)

Ecological economic benefit and ecological economic efficiency are two terms with similar meanings. The former reflects absolute value and the latter relative value.

For a long time, people have only focused on economic benefit and economic efficiency. Economic benefit is the difference between economic returns and economic costs, while economic efficiency is the ratio of economic returns to economic costs. Such benefit (efficiency) evaluation methods have a significant defect: they ignore the existence of ecological value and ecological costs.

Therefore, ecological economic benefit is a very important part of ecological economics. On the one hand, it uses a pair of core constituents of economics, costs and returns. On the other hand, it significantly revises traditional economics.

The economic benefit is the difference between ecological economic returns and ecological economic costs, i.e.:

$$\text{Ecological economic benefit} = \text{ecological economic return} \\ - \text{ecological economic cost}$$

Economic efficiency is the ratio of ecological economic return to ecological economic cost, i.e.:

$$\text{Ecological economic efficiency} = \text{ecological economic returns}/\text{ecological economic cost}$$

The implication of the ecological economic benefit (efficiency) is that we should not only consider economic indicators, but also pay attention to ecological indicators in the process of socio-economic and ecological development, and that we should adjust the assessment indicators so as to achieve economic ecologicalization and ecological economization.

2.2.5 The Ecological Economic System

"Institutions are the rules of the game in a society, or, more formally, they are the human-devised constraints that structure human interaction," argued U.S. leading figure of new institutional economics Douglass C. North.[2] Additionally, Daniel W. Bromley thought that institutions should be interpreted as the rules and codes of conduct that define how individuals, firms, households and other decision-making units choose their course of action.[3]

Institutions as "rules" include formal and informal rules, also known as formal institutions and informal institutions. The former mainly consists of rules that define the "responsibilities" of people in the division of labor in society, i.e. rules that define what everyone can and can't do, as well rules on punishment and on weights and measures. The latter consists mainly of values, ethical norms, moral codes, customs and ideologies. In addition to formal and informal rules, institutions also include implementation mechanisms.

With regard to ecological economic institutions, formal institutions include ecological economic laws, ecological economic regulations and ecological

[2] Douglass C.North, Institutions, Institutional Change and Economic Performance, Shanghai Joint Publishing Company, September of 1994, Page 1.

[3] Daniel W. Bromley, Economic Interests and Institutions, Shanghai Joint Publishing Company, August of 1996, Page 49.

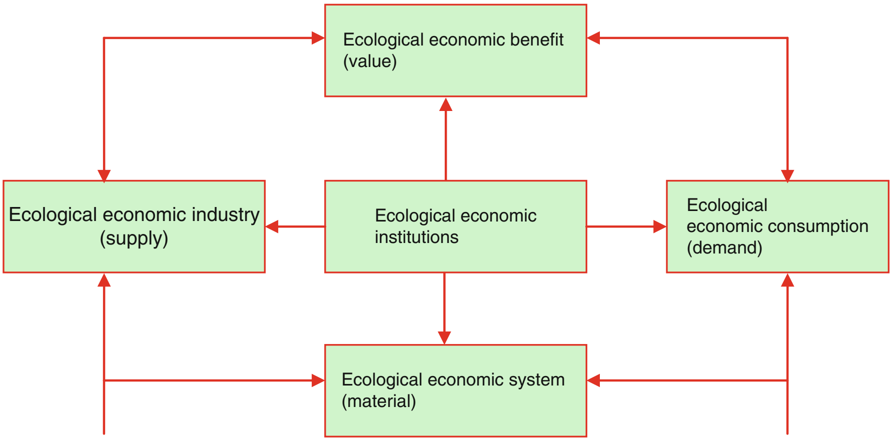


Fig. 2.1 Five areas that constitute the framework of ecological economics

economic policies. Informal institutions include ecological awareness, ecological concepts, ecological customs, ecological habits and ecological ethics. Therefore, ecological economic institutions are social rules that address ecological economic problems and facilitate coordinated ecological and economic development. Because such rules are conducive to ecological protection, they are also known as "green institutions." Ecological economic institutions operate through ecological economic policies, such as policies on ecological protection and ecological industry.

The above-mentioned five scopes of ecological economics are not isolated but interrelated. They constitute the basic framework of ecological economics. The relations among them are illustrated in Fig. 2.1.

In Fig. 2.1, the ecological economic system constitutes the foundation of ecological economics; ecological economic benefit is the objective, and ecological economic industry, consumption and institutions are the means. The foundation-the ecological economic system and the objective–of ecological economic benefit is bridged by ecological economic industry, consumption and institutions. Ecological economic industry and consumption make up the relation between the demand and supply of ecological products in the market, which are subject to the force of market mechanisms and the influence of institutions. The leverage of the ecological economic system for ecological economic benefit will be driven by market mechanisms and affected by the institutions. This shows that ecological economic institutions have a nature of originality.

2.3 Basic Laws of Ecological Economics

The essential relations between objective things in the process of development are universal. Laws refer to the aspects inherent in things and hidden behind phenomena, which dictate or govern phenomena. There are essential relations between the same types of phenomena or stable relations between essences, and the relatively stable aspects of ever-changing phenomena. Laws work repeatedly. As long as necessary conditions are in place, phenomena conforming to laws will recur. Laws can be categorized into natural laws, social laws and thinking laws. Natural laws and social laws are objective laws of the physical universe, but differ in their forms of manifestation. Natural laws reveal themselves in their unconscious and blind interactions with nature. Social laws must be embodied in people's conscious actions. Thinking laws reflect the response of people's subjective thinking to the objective laws of the physical universe.

Ecological economics follows natural laws, such as the first and second laws of thermodynamics and the principle of limited environmental capacity. It also follows economic laws, including the law of supply and demand, the law of diminishing marginal utility, the law of diminishing marginal returns, and the principle of resource scarcity. On top of that, it also forms some of its own laws, such as the law of coordinated ecological economic development, the law of ecological economic industry chain, the law of diminishing ecological demands and the law of increasing ecological value.

2.3.1 The Law of Coordinated Ecological Economic Development

The following can be derived from the law of coordinated ecological economic development: the economic system is a subsystem of the ecosystem and is based on the ecosystem, and human economic activities are subject to the capacity limits of the ecosystem; the ecological economic system is made up of the ecosystem and the economic system is the unity of a pair of contradictions. The adaptation of the two systems to each other will result in an ecological economic balance. On the contrary, the contradiction between the two systems will lead to a state of ecological economic imbalance; men can keep their own economic activities at a moderate level by learning about the ecological economic system so as to attain the coordinated development of the ecological economic system. This is the basic law governing the overall laws of modern economic development that serve as ecological economic organisms.

The law has the following three characteristics:

First, connections of the ecological economic system. The connections refer to the wide-ranging connections between the ecosystem and the economic system, and the wide-ranging connections among elements respectively within the ecosystem, the economic system and the ecological economic system. Men can't simply sever these connections or put themselves above nature.

Second, contradictions of the ecological economic system. In the ecological economic system, there are two outstanding contradictions–the contradiction between the ever-growing demand of the economic system for natural resources and the limited supply of natural resources; and the contradiction between increasing waste in the economic system and limited environmental capacity in the ecosystem. The two contradictions are universal. Therefore, people must face them squarely and take necessary measures, including taking the development of alternative resources into full consideration when exploiting and using non-renewable resources, maintaining a balance between the mining rate and growth rate of resources when exploiting and using renewable resources, and properly disposing of and recycling waste from the economic system to the greatest extent.

Third, the adaptability of men. Although men can't create laws, they can comply with laws, because there are rules to follow. Actually, even the ecosystem does not stay the same. Purely natural ecosystems virtually don't exist. Instead, ecosystems are dynamically evolving. Therefore, men can follow ecological laws to innovate ecosystems and enhance the harmony between men and nature in accordance with ecological economic laws.

2.3.2 The Law of Ecological Economic Industry Chain

An important characteristic of the ecosystem is the existence of a biological chain. Also known as the food chain, the biological chain refers to a chain or web of interdependent connections in which plants, animals and microorganisms provide food for each other. The biological chain integrates living and non-living things, producers and consumers, consumers and consumers into a whole. Energy and materials are transferred from one living thing to another living thing along the biological chain, which in turn establishes a reliable cycle of materials in nature.

Different ecosystems have different compositions and vary in their forms of trophic structures. But they are all shown as food chains and food webs comprised of different trophic levels. Each link on the food chain is called a trophic level. In each ecosystem, there are many food chains that intertwine and connect with each other to form a complicated food web which reflects the trophic positions of and interrelations among different species within an ecosystem. In food chains and food webs, different biological function groups belong to different trophic levels.

Different compositions of an ecosystem are linked with trophic connections to form a trophic relation that closely links living things and the environment to create three major function groups centering on producers, consumers and decomposers. Hence the trophic structure of an ecosystem illustrated in Fig. 2.2.

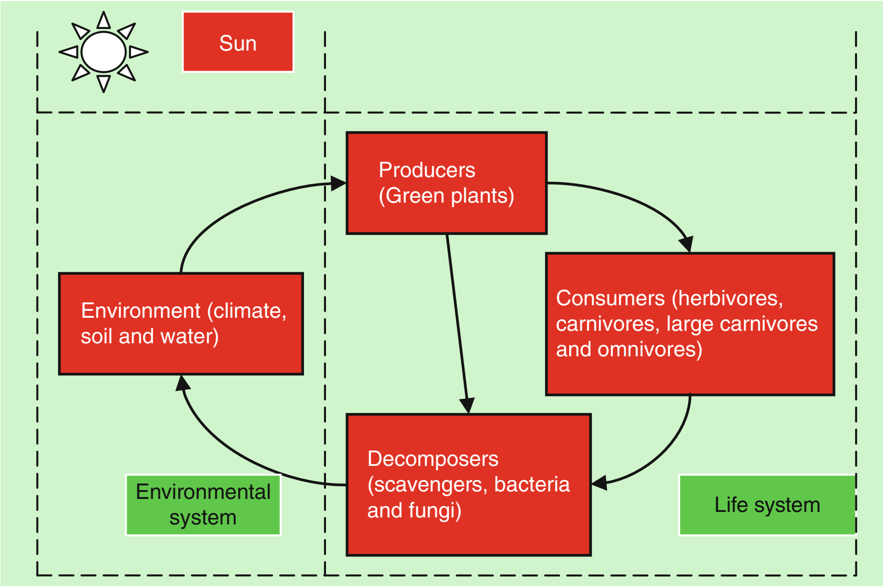


Fig. 2.2 Trophic structure of an ecosystem

The introduction of the ecological chain theory of the ecosystem into the ecological economic system gives rise to the law of ecological industry chain. The ecological industry chain refers to the alliance of businesses with industry connections within a certain area by simulating the biological chain relations among developers, producers, consumers and decomposers within a natural ecosystem linked by resources (raw materials, byproducts, information, funds and human resources). The ecological industry chain can reduce the emission of waste or even achieve zero emissions, mitigate environmental pressures and address resource shortages. By creating a dissipative structure, we can establish an ecological industry chain featuring systematic integrity, orderliness, diversity and functional controllability so to achieve the goals of optimizing output and serving society and the economy.

To plan and operate an ecological industry chain, we must leverage the cost-return analysis tool to reduce transaction costs within the ecological industry chain and ensure a smooth and cost-efficient operation of the whole ecological industry chain, so as to realize an ecological industry boasting market attractiveness and broad prospects. By following this law to plan the intra-business divisions, inter-business divisions and distribution, inter-industry divisions and coordination, we can achieve both ecological and economic benefits, thus attaining the goal of ecological economic benefit maximization.

The ecological industry chain consists of intra-enterprise, intra-park (inter-enterprise) and inter-industry levels.

The intra-enterprise ecological industry chain refers to the ecological industry chain among different workshops within the same enterprise, in which waste from upstream workshops becomes the material of midstream workshops whose waste in turn become the material of the downstream workshop.

The intra-park (inter-enterprise) ecological industry chain refers to the ecological industry among independent accounting enterprises, in which waste from upstream enterprises become the materials of midstream enterprises whose waste in turn becomes the material of downstream enterprises. Ecological industry parks are designed according to this principle. Within an ecological industry park, we should build mutual coordination and co-existence among enterprises, maximize the utilization of resources, minimize the negative impact on the environment and create a new model that organically combines industrial production and environmental protection for sustainable industrial development. Enterprises within the park complement each other. The mutually complementary enterprises share water, power, road, information and other infrastructures to reduce resource consumption and costs. Similarly to a natural ecosystem, there are many enterprises in an ecological industry park which rely on and interact with each other in an upstream and downstream relationship for industrial metabolism. They can also, according to the hierarchy of ecological chains, be categorized into producers, consumers and decomposers. That is to say, the industrial ecological economic system has an industrial ecological chain similar to the ecological chain in a natural ecosystem, serving as both an energy transfer chain and also a material transfer chain.

The inter-industry ecological industry chain refers to the ecological industry chain similar to an ecological chain, which is formed among different industrial sectors. For instance, the industrial sector produces plastic membranes which are used by the agricultural sector. After the used plastic membrane is scrapped by the agricultural sector, it is collected by the service sector and then sent to the industrial sector for reproduction.

2.3.3 The Law of Increasing Ecological Demand

Demand refers to the amount of a certain commodity or service that consumers are willing and able to buy at each price within a certain period of time. It is the unity of consumers' subjective desire and objective ability. From the perspective of objective ability, as a result of rapid socio-economic development, people's incomes will increase accordingly, and so will their payment capacity. From the perspective of subjective desire, as people's living standards are improved, their requirements on quality of living and life will also increase. Because of the joint actions of the two factors, people's demand for ecological products will keep growing. Ecological products are a general name for ecological quality and ecological economic products. According to economics, and in line with the income elasticity of demand, all commodities can be divided into several categories. If the elasticity is larger than 1, it indicates that as income grows, the size of the purchase will become relatively larger. Such commodities are high-end or luxury goods. If the elasticity is larger than 0 but smaller than 1, it indicates that the demand rises as a result of an income increase, but the rise in demand is smaller than the increase in income. Such commodities are necessities of life. If the elasticity is a negative value, it indicates that when income increases, the demand falls. Such commodities are low-end goods.

Ecological demand is a general term for consumers' demands for ecological quality and ecological economic products. Ecological supply is a general term for producers' supply of ecological quality and ecological economic products.

High-quality ecological environments and ecological economic products are typically high-end goods. When there is no adequate food and clothing, people's first goal is to survive, and the pursuit of a high-quality ecological environment and ecological economic products is not on the agenda. But when they enter a well-off or even an affluent society, as their income increases, their demand for high-end goods, such as high-quality ecological environments and ecological economic products, grows at a higher rate.

The law of increasing ecological demand refers to the fact that as consumers' income increases, their ecological demand will progressively increase. Such a trend is manifested by the demand curve of ecological products, which is moving toward the top right at a faster pace. This law is illustrated in Fig. 2.3.

Figure 2.3 shows that the initial position of the ecological demand curve is at D1. But as people's income grows, the ecological demand rises, and the ecological demand curve is moved to D2.

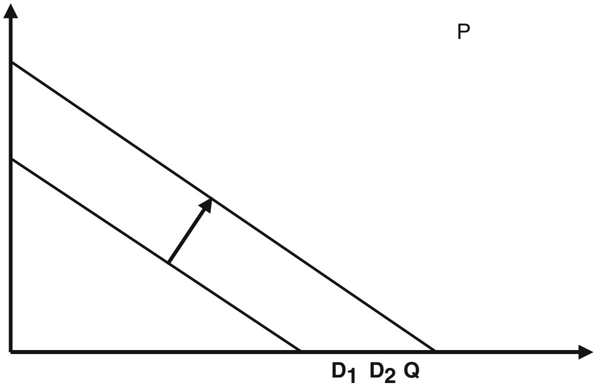
From the principle of supply and demand, we learn that if the supply of ecological products by producers remains unchanged, the rising ecological demand will result in an increase in the price of ecological products; if the supply of ecological products by producers decreases, the rising ecological demand will lead to a dramatic increase in the price of ecological products; if the supply of ecological products by producers increases, the rising ecological demand will ease up the increase in the price of ecological products.

As such, in view of rising ecological demand, the supply and demand of ecological products can be balanced by increasing the ecological supply.

2.3.4 The Law of Increasing Ecological Value

The law of increasing ecological value refers to the following: the ecology is not a free good without value, but a valuable economic resource; as a result of socio-economic growth, ecological resources will become increasingly scarce, and the ecological value will grow; as the ecological value displays a trend of progressive growth, men can make an ecological investment in the way they make economic investments to increase the value of ecological capital; as the ecological capital features strong public and external traits, only when an ecological protection and compensation mechanism is established can people be stimulated to engage in ecological investment activities.

Fig. 2.3 Increase trend of ecological demand



The law includes the following characteristics:

First, ecological resources are valuable and scarce. Therefore, we should establish a theory of valuable ecology and then economize the ecology, as described in *Green is Gold* by Patrick Carson and Julia Moulden. That is to say, the protection of ecology equals the protection of productivity.

Second, the scarcity of ecological resources is on the rise. The conflict between people's unlimited demand for natural resources and limited natural resources means that the ecosystem can't supply results in an ever-increasing scarcity of natural resources.

Third, ecological investment is an essential way to increase the value of ecological capital. In the context that ecology is valuable and on the premise of ecological economization, ecological investment is as significant as economic investment.

Fourth, ecological investment should be spurred through institutional innovation. Because of the special attributes of ecological resources and ecological products, people's ecological investment enthusiasm should be mobilized through institutional innovations to ensure an adequate supply of ecological resources and ecological products.

In addition to the aforementioned four ecological economic laws, there are also many other ecological economic laws which need to be summarized, refined and generalized by ecological economic scholars so as to better guide ecological economic practices.

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Chapter 3
Exploration of Deep-seated Ecological Economic Problems

Jiang Xuemin and Ren Long

Up until now, the academic community has defined ecological economics as an edge discipline featuring distant hybridization and a basic theoretical discipline for implementing a strategy of sustainable development. It is undoubtedly quite right, and accepted by most scholars.

Depending on the scale and nature of problems in the economy and society, this discipline can be roughly categorized into macro development strategies and policies, and micro economic patterns and technical roadmaps. With a country or a region as the regulation object, the former grasps and builds the ecological economic system as a whole, optimizes its structure, and distributes economic factors in a reasonable manner to establish a sustainable development network featuring comprehensive coordination and smooth information, energy, material and capital flows. The scale and region of micro ecological economy is relatively smaller, such as to do with the implementation of an ecological economic system in a small watershed, a lake, a hill, a piece of woodland, a piece of farmland, a county, a village or a household. It is the foundation of macro control, and must be guided by macro ecological economic theories. Its task is to apply ecological and economic sciences and basic theories of adjacent and related disciplines, closely integrate the practical issues in intermingling areas in ecological and social development, build an ecological economic system featuring harmony, orderliness, optimum structure, diverse functions and steadily growing productivity, maintain the balance between population, resources, environment, ecological civilization and social development and eventually optimize ecological economic benefits.

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3.1 What Are Deep-seated Ecological Economic Problems?

We can hardly define deep-seated ecological economic problems. But men have strongly felt the existence of such ecological economic problems. In more than 40 years since the emergence of ecological economics, the earth's ecosystem has experienced some worrisome changes. Early ecological economic problems arose without being sensed or felt by people. At that time, people thought the ecological, resource and environmental problems could be easily solved through technological changes, legal proceedings and economic growth. But nowadays, the ecological economic problems are tangible and strongly sensed and seen by people. They are manifested in people's daily necessities, rest, work and entertainment, and almost every corner of the earth.

Ecological economics is different from economic science or ecological science in its study of objects. It integrates the basic theories of economic science and the principles of ecological science to analyze the mutual relations between ecological and economic phenomena. Specifically, ecological economics studies the composite system resulting from a coupling ecosystem and economic system and its movement laws. The ecosystem is a combination of life system and environmental system in a specific space. The life system refers to the assemblage of animals, plants, micro-organisms and other living organisms. The environmental system is the assemblage of light, heat, water, air, soil and other abiotic factors. There is a flow of materials, energy and information among all living organisms and the inorganic environment in a specific space, and certain automatic adjustments and organization functions. Any unit featuring such basic functionality is an ecosystem. It can be a forest, a lake, a piece of grassland or a combination of the plant and animal communities and the environment in an area. Ecosystems at different levels and of various sizes on the earth inlay and fuse with each other to form a gigantic, multi-layered and orderly physical body, also known as the biosphere, the largest ecosystem on the earth. Ecology is a science that studies these ecosystems, specifically seas, forests, wetlands, grasslands, farmlands, rivers and other natural and artificial ecosystems.

There are multiple explanations for the economic system. Purely from the perspective of production processes, the economic system is the process in which people transform natural resources into economic and social wealth through material inputs, energy consumption and information control by specific technical procedures and means. By its nature, it constitutes a system for ecological economic reproduction. It not only includes the ecological economic relations among industry, agriculture, minerals and energy, but also necessarily contains the movements of commercial and banking capital, as well as the movements of human resources, human capital and knowledge capital. This reveals the idea of systematology, i.e. all components rely on and interact with each other. The system can be a factory, a mine, a village, a city or an economic zone. The overall social productivity operates along with the circular movements of social production, distribution, exchange and consumption. These economic activities, as well as the institutions, organizations and systems established for them, constitute the macro ecological economic system of a country.

Since the emergence of human economic activities, socio-economic systems and natural ecosystems have been objectively related. Men, as the subject of economic systems, take the natural ecosystem as their living environment. All the material data necessary for production, distribution and exchange in the economic system is derived directly or indirectly from the ecosystem. As such, the ecosystem is the material foundation for men's existence and economic activities. On the other hand, to get more material data from the ecosystem to meet the ever-growing demands of the economic system, men transform and affect the ecosystem by carrying out economic activities and adopting technical means to reshape the landscape of natural ecology. The transformation of a natural ecological system by men's economic activities may lead to two different outcomes: the natural ecosystem increasingly improves as a result of the transformation and impact, and consequently becomes more suitable for men's survival and development, providing more and more material data to meet the demands of the economic system so as to facilitate sustained socio-economic growth; or the ecosystem deteriorates as a result of the transformation and impact, and consequently the system productivity declines, which constrains socio-economic progress or even endangers men's survival.

Whether the outcome will be a result of the transformation of and impact on the natural ecosystem by men's economic activities mainly depends on the way and degree those economic activities interfere with the natural ecosystem. So when men transform, develop and affect the natural ecosystem, what production and economic patterns should be taken so that the natural ecosystem can be increasingly improved to meet the ever-growing demand of the economic system and eventually facilitate sustained socio-economic development? What laws can be followed? This is undoubtedly a major issue that merits profound study. However, because of the limitations of the discipline, neither traditional economics nor ecology touches on the issue. Consequently, the responsibility to study this major issue falls to ecological economics. Or, rather, the objective requirements of socio-economic growth give rise to a merging edge discipline– ecological economics. In this sense, ecological economics is the science of how men's economic activities properly interfere with, affect and transform the natural ecosystem to promote coordinated ecological, economic and social development.

On the whole, ecological economics is a theoretical discipline, a study of the composite system which results from the mutual promotion and interaction between the ecosystem and the economic system – the ecological economic system, and the operating mechanisms and laws of the system. It checks and reveals the universal and inherent relations between economy and ecology and the essential characteristics so as to guide people to correctly grasp the dialectal relations between economy and ecology. The concepts, principles and areas of scope it involves are all highly abstract. But ecological economics is also a very practical discipline. It does not involve purely theoretical research to be carried out in a study. Instead, it comes from practice, is applied to guide practice, and is constantly enriched, developed and improved in practice. Ecological economics is closely related to various socio-economic aspects. The dissemination and application of research achievements of this discipline will play an active role in and exert profound influence on socio-economic growth and the improvement of people's livelihoods.

3.2 Background for the Emergence of Ecological Economics

First, ecological economics emerged as a result of socio-economic development, and it was a product of socio-economic practices. As a discipline, ecological economics didn't develop rapidly and did not draw the attention of all sectors of society by chance. Instead, it has an objective basis backed up by socio-economic development practices, and it is the inevitable result when productivity has developed to a certain level. The birth of a discipline comes from the need of practice. Only when issues arise that need to be studied can it be possible for disciplines that study these issues to emerge. The direct cause for the birth of ecological economics is the existence of ecological economic issues, i.e. the negative impacts of men's economic activities on natural ecology and economy itself.

Ecological economic issues didn't just emerge yesterday. In some sense, they have existed since the start of human economic activities. However, for a long time, social productivity remained quite low, and so did men's demand for and intervention in natural resources and their ability to affect the natural ecology. In contrast, the demand for an abundant nature was virtually unlimited. Therefore, the ecological economic issues that appeared were generally confined to a small area and scale, and didn't have a substantive impact on socio-economic development. However, the situation has made a sudden change since the industrial revolution in the nineteenth century. First, the productivity created by the industrial revolution was far greater than the sum of productivity of all previous centuries. The scope of such intervention and impact went far beyond the surface of the earth. Men have left their footprints of their conquest of nature tens of thousands of meters up in the sky and several thousand meters deep in the ground, i.e. the biosphere as we know it. Many things that were unattainable or unimaginable in the past have now become reality due to the rapid progress of science and technology. On the other hand, as a result of increasing productivity and a rapidly rising population, the demand of men for nature has grown to a scale never seen before. To get more resources from nature to meet the ever-growing demands of life and work, men have significantly increased the frequency and intensity of their intervention in nature. The rapidly-changing science and technologies provide adequate means for such intervention. Nevertheless, men have now finally realized that natural resources are not unlimited, as they imagined in the past. The extra-intense and improper claim has exceeded the allowable limit of the natural ecosystem, leading to a series of severe consequences: the excessive consumption and waste of energy leads to demand over supply; the gap between the explosive population and the grain output is widening; the overcutting, over-reclamation of land and the destruction of grasslands lead to large-scale water loss and soil erosion, silting rivers and land desertification, which in turn exacerbates the shortage of food and resources; a large quantity of waste generated by modern industry is unscrupulously discharged into rivers, lakes and seas, harming the structure and functionality of the ecosystem, lowering the productivity of nature, seriously polluting the air, water and land, and directly harming men's health with enriched harmful materials in the food chain. More seriously, these issues are no longer confined to a small area or scope as in the past. Instead, they have turned into worldwide "global issues" that constitute the greatest barriers to smooth socio-economic progress, and hence attracted much attention and concern. From the 1950s on, more and more people have started to study and explore the causes of ecological economic issues, their development trends, preventive measures and solutions. On this basis, ecological economics was born. In this sense, ecological economics is the product of "postindustrial society," and the inevitable result when social productivity has reached a certain level.

In connection with this, human society has confronted a stark contradiction since industrialization: the ever-growing demand of economic development for natural resources, and the limited quantity of ecosystems and their renewal capacity. The relations and solidarity between men and nature have never been so close and inseparable. As a result, when making and designing future socio-economic development patterns, men must not only consider pure economic incentives. Instead, they must also take economy, society and ecology into consideration as a whole. This poses an urgent need for new science that studies and explores the laws of coordinated development and provides theoretical guidance for building a society of sustained and stable development. Ecological economics is a new discipline of economics that arises in response to this need.

Second, breakthroughs in ecology provide a theoretical foundation for ecological economics, which is a science that studies the ecological economic system and its movement laws. It was the emergence of the idea of the ecosystem that made it possible to study the ecosystem and the economic system as a whole. Ecology came out about a century earlier than ecological economics. It was a science first proposed by German zoologist Ernst Haeckelin in 1866 and defined as studying the mutual relations between biological organisms and the inorganic environment. Since its birth, this science has made much progress and a series of significant leaps. In particular, the theory of "Systems Ecology" proposed by British botanist Arthur George Tansley in 1934 significantly enriched the content of ecology and laid a theoretical foundation in the natural sciences for the birth of ecological economics.

The birth of ecological economics should also be attributed to the breakthroughs made in ecology on the study of socio-economic issues. Traditional ecology only focused on the relations between living things and the environment without touching on socio-economic issues. In the mid-1920s, U.S. scientist Lionel Mckenzie first applied the concepts of phytoecology and zooecology to the study of the human community and society, putting forward the term ecological economics and maintaining that economic analysis couldn't ignore the ecological process.

However, although the ecological economic study by Mekenzie and other scholars started to touch on socio-economic problems, it didn't involve much of the content of ecological economics. It was U.S. marine biologist Rachel Carson who first combined socio-economic issues to carry out ecological studies. She published a popular science book titled *Silent Spring* in 1962, which vividly depicted the harm caused by the abuse of pesticides in the U.S. and revealed the impact of modern industry on natural ecology. Since then, a series of works on socio-economic issues has been published, ushering ecology into a new age of being an edge discipline when it closely combined and developed crosswise with socio-economic issues to give rise to the economics of public naissance, pollution economics, environmental economics and resource economics, and eventually a another new edge discipline – ecological economics. U.S. economist Kenneth Ewart Boulding first officially proposed the concept of ecological economics in an important paper, *A Science – Ecological Economics,* in the late 1960s. In this paper, he creatively expounded on the defects of the application of market mechanisms for controlling populations, regulating the allocation of consumables, developing and utilizing resources, environmental pollution and the application of the GDP to measure human welfare. In addition, he also introduced the famous Spaceship Economy Theory, which caused enormous repercussions. Since then, works on ecological economic issues came one after another, with the content going far beyond the scope of ecology. Gradually, an independent discipline of economics came into being. From this development process, we can see the relations between ecological economics and modern ecology. In some sense, without the study made by ecologists on socio-economic issues, there wouldn't be modern ecological economics as it is today. The breakthroughs in ecology finally paved the way for the emergence of ecological economics.

Third, the trend of horizontal integration in scientific development spurred the birth of ecological economics. The history of scientific development can be roughly divided into three phases. Initially, people studied natural and social phenomena in general, and called them "philosophy" or "mathematics." This was a low-level and primitive generalization. Later on, with the increase in productivity, many branches were derived from a general discipline, and they focused on natural and social phenomena from different angles. Modern scientific research develops both horizontally and vertically. On the one hand, it integrates many disciplines to comprehensively study some macro issues or the "joint parts" of several disciplines, giving rise to a new edge discipline resulting from the disciplinary inter-infiltration. On the other hand, the disciplinary division gets increasingly refined and research more profound, giving rise to new disciplines. Ecological economics is formed and advanced in response to the need for modern disciplinary development. To study ecological economic issues, we can't purely rely on ecology or economics, because they are integrated and can only be addressed through comprehensive study that involves ecology, economics and other disciplines and eventually leads to an edge discipline that spans the natural sciences and social science.

3.3 The Principle Ecological Economic Laws

Ecological economic laws refer to the essential characteristics of the paradoxical movements of the ecological economic system. When carrying out ecological economic practices, we must follow ecological economic laws to obtain good ecological economic benefits. Due to the limit of space, we can't fully explicate ecological economic laws here. Instead, we will only give a briefing on several major ecological economic laws that are closely related to the design process.

3.3.1 Law of Coordinated Development

The steady state of the ecosystem and the development of the economic system contradict each other, but they are not absolutely opposite. In the ecological economic system, there is a mechanism in place for coordination between economic growth and ecological stability. As long as people establish this mechanism by regulating the ecological economic system, the economy and ecology can be developed in a coordinated manner. This is the objective law for the fundamental contradiction between ecology and economy, called the law of coordinated ecological economic development. It is the basic law of the ecological economic system. Like other laws that work alone, the law of coordinated ecological economic development has its own form and characteristics.

First, the law of coordinated ecological economic development bases its effect on the pursuit of a multi-factor, comprehensive objective. This objective is neither to optimize the economy nor to purely optimize the ecology, but to achieve ecological economic optimization so that the system output can be maximized without exceeding the maximum threshold allowed by the system's stability mechanism. How can it be regulated? We should, depending on specific conditions, carry out an ecological economic diagnosis. Economic means can be adopted, such as controlling the issue of money and investment so as to control the development of ecology and resources. Technical means can be leveraged, such as cutting the cost by applying energy-efficient technologies or developing clean energy technologies. Moreover, the development of some resources can be restricted through government intervention, including laws and regulations banning fishing and hunting. All measures can be taken as long as they are conducive to the coordinated development of economy, resources, environment and society.

Second, the law of coordinated ecological economic development has a far-reaching effect, i.e. it displays a long-term general trend, not necessarily a direct linear causal relationship. This is because the structure of the ecosystem is different from that of the economic system, lacking the strict economic and technological connections between and among various parts and factors, as in the economic system. Moreover, the reproduction cycle of the ecosystem is generally longer than that of the economic system, and its advancement or degradation is a long process. Therefore, on many occasions, changes in ecology and economy are asynchronous. Improvements in the ecosystem will not necessarily be manifested in economic benefits. Similarly, disruption of ecosystem stability will not necessarily affect economic growth. On the contrary, sometimes there is a trend of negative correlation. For instance, the predatory exploitation of natural resources will bring large economic benefits in a certain period of time. The emission of industrial waste without proper treatment will increase profits by reducing the production cost. The returning of cultivated land to the forest on steep slopes will reduce the output of grain, but the economic and ecological benefits of afforestation won't come out until several years later. This characteristic of the law of coordinated ecological economic development indicates that when people follow this law, it is possible that they won't achieve the desired result in a certain period of time. But it is not that the law "malfunctions." It's just it is hidden by some temporary superficial phenomena. As time goes by and the contradiction develops, the role of the law will gradually be displayed.

Third, associated with this is a delay in the role of the law of coordinated ecological economic development. That is to say, when people's behavior breaches the law, the law will normally demonstrate its force in the form of "punishment" afterwards. Many facts in the socio-economic development process have repeatedly proved and displayed such an irresistible role for the law: reclaiming farmland by deforestation, reclaiming land from lakes, overgrazing, overfishing, uncontrolled emissions and discharges of waste water, gases and solid waste from industry, as well as the production and economic growth patterns of high input, high pollution, high destruction and low efficiency processes: all will bring temporary economic benefits. But they will be followed by severe water and soil erosion, soil desertification, grassland degradation, resource depletion and environmental deterioration, which will hinder further economic growth. This also proves true from the reverse side– the law of coordinated ecological economic development is an objective law independent of men's will.

3.3.2 Systematic Laws of the Ecological Economic System

The ecological economic system is a group consisting of several ecological economic laws. This group includes the law of integrity and the law of hierarchy, both the laws reflecting qualitative changes and the laws reflecting quantitative changes, and both are general laws that run through the whole ecological economic development process, such as the law of coordinated ecological economic development, and the phasic laws that only work at certain stages. These laws constitute the law system of the ecological economic system. In this system, the systematic law of ecological economy plays a dominant and decisive role, dictating the existence and development of other laws.

3.3.3 The Integrity Law of the Ecological Economic System

The integrity law governs the whole ecological economic system and decides the overall development trend of the ecological economic system. In addition to the law of coordinated ecological economic development, the integrity law also includes the law of ecological economic balance, the law of ecological economic benefit and the law of proportionate input and output.

Ecological Economic Balance The implication of this law is as follows: the ecological economic system requires a dynamic balance, not a pure economic balance or a pure ecological balance, but a unity of the two. Only when ecological economic balance is achieved can the ecological economic system grow in a sound manner into an efficient, stable and optimal system. Of the ecological and economic balances, the ecological system is primary and dominant, serving as the material basis for economic balance. Any loss of ecological balance will eventually have repercussions for the economy, leading to or exacerbating the economic imbalance. Therefore, people must strive to develop the economy on the premise of maintaining ecological balance, i.e. achieving ecological economic balance.

Ecological Economic Benefit The implication of this law is as follows: the best benefit from the ecological economic system comes from the unity of economic, ecologic and social benefits. Among the three benefits, there is a dialectical relationship of interrelation, interaction and reciprocal causation. The economic benefit generally appears as a direct and near-term benefit, while the ecological benefit and the social benefit are indirect and long-term. For instance, timber and other forest products can be obtained through afforestation. This is a direct economic benefit. The roles of forests in preserving water and soil, regulating the climate and beautifying the environment are ecological and social benefits. Economic benefits and ecological benefits are contradictory to some extent, but they are not absolutely mutually exclusive. Under certain conditions, they can be united and balanced. According to the law of ecological economics, the unity of ecological and economic benefits is the ultimate goal of socio-economic development.

Proportionate Input and Output The ecological economic system is a composite system resulting from a mutually coupling ecosystem and an economic system between which materials are circulated and energy flows through technical intermediaries. Under certain technical conditions, human labor imports a certain quantity of materials and energy into the ecosystem (input) through the economic system, and then exports a certain quantity of materials and energy from the ecosystem to the economic system (output) through reproduction. This is the law of proportionate input and output of the ecological economic system. To ensure a normal and smooth reproduction process in the ecological economic system, an appropriate proportion must be maintained between the input and the output. The material "taken away" from the ecosystem must be replenished or "returned" to the ecosystem in a proper way. This role is more significant in the agricultural ecological economic system. For instance, after agricultural products are harvested from the land, some materials and energy are exported out of the agricultural ecological economic system. So a proportionate quantity of materials and energy must be re-imported through fertilization and irrigation to maintain the nutrient balance of land and achieve the high and stable yields of the agricultural ecological economic system.

3.3.4 The Hierarchy Law of the Ecological Economic System

The hierarchy law refers to the law that governs how a constituent of the ecological economic system evolves and interacts with other constituents. It doesn't decide the general development trend of the system, but restricts and influences the development of the whole system to a certain extent. The ecological economic system has many hierarchy laws. We will just name a few here.

The Law of Quantitative Proportion Combination The constituents of the ecological economic system should not only be in a certain sequence, they should also maintain a roughly fixed proportion so that the system can carry out normal circulation and transformation. For instance, there is a quantitative proportion between agricultural plants and agricultural animals in the agricultural ecological economic system, within agricultural plants (such as between crops and woods), within forestry (such as between coniferous trees and broad-leaved trees), and within livestock (such as between and among pigs, cows, horses and sheep), and finally between proportions of land used for different purposes and the proportion between different nutritional ingredients in the soil, such as nitrogen, phosphate and potassium. This law requires that comprehensive plans and reasonable arrangements should be made for the development of farming, forestry, animal husbandry and fishing in an all-round manner.

The Law of Best Sustained Yield The so-called best sustained yield refers to the maximum total yield in a certain period of time (such as 1 or 10 years) that includes several harvests. This law implies that there is a maximum proportion between the reproductive capacity of biological populations in agriculture (the individual increase rates) and the yield. When this proportion is achieved, the sustained yield can be maximized. The best proportion can be deduced from certain modern biological and mathematical formulas. This law requires that people should not exercise predatory management, such as draining the pond to get all the fish, or killing the goose that lays the golden eggs, and that when engaged in logging, fishing or slaughtering, people shouldn't only consider the one-time maximum yield and compromise on the reproductive capacity of biological populations in agriculture. If people understand and master this law, they can actively maintain a balance between yield and individual population growth to get maximized yields and optimum economic benefits.

In addition to the mentioned ecological economic laws, there are also several other laws, including the law of mutual adaptation between biology and environment for synergy, the law of endless material cycling and economic use, the law of self feedback on ecological economy for value appreciation, the law of irreversible ecological economic evolution, the law of the whole of functions being greater than the sum of their parts, etc. Among these laws, some are on the nature of the ecological economic system, such as the law of ecological economic balance, and some are on the quantity, such as the law of best sustained yield. These laws reflect the essential connections between economy and ecology from different aspects and angles, and the motion and change characteristics of the ecological economic system.

Finally, it is necessary to discuss the relations between ecological economic laws, economic laws and ecological laws. Economic laws are common among economic phenomena that figure in the process of socio-economic development, the essential connections among economic phenomena and the intrinsic inevitability of developing economic phenomena. This notion is widely accepted. But the problem is how to understand the implications of "economic phenomena." Traditional economics normally considers economic phenomena as the connections or relations between different factors within an economic system, and excludes the relations between men and nature from economic study as ecological phenomena. Indeed, as a highly evolved animal, man is a member of the ecosystem. Like other animals and plants, man has an ecological relation with the ecology and other living things. But as the subject of economic activities, man is also social. He exchanges materials with nature. This relationship is the premise of certain social forms and economic conditions, and it aims for socio-economic development. In essence, it is an economic relation or phenomenon. The ecological economic law that reflects this relation is an economic law, but it is different from economic laws in traditional economics. Therefore, we can say that ecological economic laws are a type of socio-economic laws with more extensive functions and which apply at higher levels.

Ecological laws are the essential connections between living things and the ecological environment in the ecosystem; they are natural laws that existed and worked before human beings arrived on the scene. They are not necessarily related with human economic activities. Therefore, there are essential differences between ecological laws that are part of natural laws and the ecological economic laws that are part of economic laws. However, when human economic and social behaviors breach natural and ecological laws, it necessarily affects and offsets the efficiency and benefit of economic activities. Under this circumstance, ecological laws are transformed into externalized economic laws. The material exchange between man and nature is conducted in the biosphere, the largest ecosystem, which has an inevitable and inseparable connection with natural and ecological processes. As such, ecological economic laws and ecological laws are closed related. In some sense, we can say that ecological laws constrain the intensity and scope of the influence of economic laws. These, in the two aspects, are thus the important characteristics of ecological economic laws, enabling us to grasp the essence of ecological economic laws in a broader sense and create more space to bring ecological economic laws into full play.

Chapter 4
The Right to Use Environmental Capacity: Legislation for Energy Conservation and Emissions Reductions

Chen Huiguang, Futian Qu, and Chen Ligen

4.1 Introduction

The theory that man is an integral part of nature, as advocated by Xun Zi an ancient Chinese philosopher, indicates that man and nature are dialectically united. As an integral part of nature, man must survive in certain natural environments. However, at different stages, the environment's population carrying capacity has a certain equilibrium value. Violation of this value will result in the degradation of environmental quality and/or people's living conditions. When energy and other resources flow into the economic system, the input-output ratio is an incentive index to measure economic development. After this, they flow back into nature in the form of pollutants. The emission of major pollutants is a binding index to assess economic growth and an index to evaluate the environment's self-purification capacity.

Since the 1990s, the Chinese economy has been rising at a rapid pace, and has been characterized by a heavy industrial structure. According to international experience, China has entered the middle stage of industrialization. Due to an increase in the proportion of energy-intensive and highly polluting heavy chemical industries, this rapid economic growth comes at a high resource and environmental cost. Therefore, energy conservation and emission reductions are inevitable policy decisions to ensure sustained economic growth while preserving an ecological balance, but what is also an inevitable policy choice is to build an energy-conserving and environmentally-friendly society to cope with global climate changes. However, we still lack highly operational legal and institutional arrangements to make energy conservation and emission reductions a component of the whole society and are unable find the balance

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and coordination between economic development and resource and environmental protection. This paper is designed to provide some framework proposals for future legal actions by leveraging the theory of the right to use environmental capacity and combining its practical experience in energy conservation and emission reductions.

4.2 The Right to Use Environmental Capacity: Theory and Practice

4.2.1 The Theory of the Right to Use Environmental Capacity

Energy and other resources flow into the economic system and then flow back into nature in the form of pollutants. This poses a problem in terms of balance between the two flows: what is the appropriate level of pollutant outflow and how should we distribute the outflow among different pollutant sources so as to achieve the appropriate level? In their pursuit of balance, people have found that environmental capacity has become a scarce resource. As the price responds to the increasingly scarce resources, two innovations will be made to prevent resource loss and environmental deterioration: economic innovation, i.e. achieving a low-entropy economy, which will, for example, reduce frictions through more complete combustion to get stronger lights from natural gas or electricity; and vicarious innovation, i.e. replacing high-cost materials with low-cost ones.

As the total self-purification capacity of water, soil, atmosphere and other environmental elements, environmental capacity constitutes the limit of human activities that the environment can sustain.[1] In fact, economists have long realized that environmental quality is becoming an increasingly scarce resource. Moreover, as a public good, environmental quality has the features of being public property, and being prone to excessive use. The consequence of human activities and their impacts exceeding the capacity limit of the environment is an environmental problem, and it is called the "tragedy of the commons."The most fundamental approach to environmental problems is allotment, i.e. to allot limited environmental resources among broad human desires and demands (Xu 2003). When optimally allocating this limit according to different purposes, people gradually find that the right to possess and use environmental capacity is an economically significant right.

The magic power of the market is that the invisible hand has made an institutional innovation which is different from the aforementioned two types of innovation and can be transferred — this is called trading emission rights, i.e. the right to use environmental capacity.[2] The regulatory authorities define the emission cap and

[1] In addition to the environmental capacity comprised of these natural environment factors, there is also the environmental capacity made up of engineering environment factors and not included in this paper, such as sewage treatment facilities.

[2] If the trading is designed to efficiently distribute resources and solve conflicts, the right must be transferrable.

issue emission permits according to the cap, and emission permits can be bought and sold in the market. This institution was first raised by U.S. economist J. H. Dales, who was enlightened by the book *The Problem of Social Costs* in which R. H. Coase deemed the production factors (the emission of dust, noise, smell, etc.) as rights, thus providing a property method to address pollution. Emissions trading was first adopted in the U.S. and Germany as an economic means for environmental management. Then it was stabilized as a legal instrument. After the right to use the environmental capacity became a right that could be allocated, the transferability exerted a far-reaching impact on the allocation of resources, effectively avoiding the frequent occurrence of the "tragedy of the commons." In addition, it pointed out an approach to privatizing public laws for the effective enforcement of environmental laws. As such, Chinese legal experts and scholars have conducted effective research on the coordination and exchange between environmental laws and civil laws, and have explored theories on environmental rights privatization and ways to protect environmental rights through civil laws. They also made a design for transforming environmental rights into real rights, established the right to use environmental capacity (or emission rights) and found a legal carrier for the legitimate transfer of environmental capacity. Eventually, a mechanism for coordinating civil laws and environmental laws can be put in place, and the long-standing conflicts between the economic value and the ecological value of environmental resources can be addressed.

4.2.2 Chinese and Foreign Mechanisms for Trading the Right to Use Environmental Capacity

4.2.2.1 U.S. Bubbles Policy and Emissions Trading Policy

The first institutional and public policy design for the right to use environmental capacity was the pilot project on emissions training launched by the U.S. Environmental Protection Agency in 1974 in line with the *Clean Air Act,* which was designed to improve regional air quality. The Bubbles Policy enacted in the *Clean Air Act* in 1977 was a continuation of market-oriented and legalized environmental and economic policies. As an emissions offset policy, the idea is that within a certain "air bubble," the emission of new pollution sources equals the reduced emissions of old pollution sources, and total emissions resulting from offsetting the emissions of new and old pollution sources should not exceed the environmental capacity of the region (Lv 2000). On this basis, a whole set of emissions trading systems with bubble, offset, banking and netting as the core components was gradually established in the 1970s and 1980s. The emissions trading policy adopted in the 1990s covered the emissions trading of SO_2. The operation system of the SO_2 emissions trading policy includes: (1) participation in the determination of units; (2) allocation of permits; (3) trading of permits; (4) approval of permits. The implementation of the U.S. Bubbles Policy and the emissions trading policy resulted in significant economic and environmental benefits.

4.2.2.2 Pilot Project for Collecting Pollution Discharge Fees and Emissions Trading in China

In 1995, the former State Development Planning Commission and the Ministry of Finance approved the *Request for Launching a Pilot Project for Collecting Pollution Discharge Fees according to Total Water Pollution in Jiangsu Province,* which was jointly submitted by the Price Bureau of Jiangsu Province and the Finance Department of Jiangsu Province, allowing the pilot collection of pollution discharge fees according to total pollution and total control to overcome the defect of the practice of collecting pollution discharge fees according to pollution intensity. In the same year, the Standing Committee of the Shandong Provincial People's Congress adopted its *Regulations on the Prevention and Treatment of Water Pollution in Xiaoqing River Basin* to control the total amount of pollutants and collect pollution discharge fees for excessive water pollution.

In 2007, the Ministry of Finance and the State Environmental Protection Administration (the predecessor of the current Ministry of Environmental Protection) approved the pilot for compensatory use and the trading of pollutant discharge rights regarding the water pollutant discharge index in the Taihu Lake Basin of Jiangsu Province. The main components of the pilot include: (1) to establish initial prices for main water pollutant discharge rights in the Taihu Lake Basin and start initial distribution of the pollutant discharge quota as a resource on a compensatory basis; (2) to kick off the initial compensatory transfer of pollutant discharge rights for COD (Chemical Oxygen Demand) in the Taihu Lake Basin in 2008; (3) to launch the pilot of the compensatory use of pollutant discharge rights for ammonia, nitrogen and total phosphorus in the Taihu Lake Basin in 2009; (4) to gradually establish a dynamic digital trading platform for pollutant discharge rights and a trading market for main water pollutants in the Taihu Lake Basin in 2008–2010; and (5) to develop a number of total pollution control technologies and advanced management systems. This signifies that China has made significant strides in institutional and technological innovation for energy conservation and emissions reductions.

4.2.3 International Energy Conservation and Emissions Reductions Efforts

4.2.3.1 U.K. Energy Conservation and Emissions Reductions Legislation and EU Energy Policies

Energy conservation and emissions reductions in the U.K. are quite distinct, highlighted by well-established laws and regulations and significant achievements. The *Alkali Act*, the *Clean Air Act* and other legislation in the U.K. require enterprises to control air pollution. In 1995, the U.K. enacted the *Home Energy Savings Act*, launching a national energy saving campaign. By endorsing the *Climate Change Act* in 2007, the U.K. became the first country in the world that caps the emissions of greenhouse gases by legislative means and defines the emissions reduction targets in legal form. According to the act, the U.K. government should make a carbon emissions reduction budget that caps CO_2 emissions at least 15 years in advance, so that enterprises know their specific mandatory emissions reduction targets. Also, the U.K. government must submit a report on CO_2 emissions reduction to the parliament on a yearly basis. Failure to achieve the mandatory targets results in a judicial review.

Energy policies of EU countries generally focus on three aspects, energy efficiency, energy conservation and renewable energy.[3] In 2007, the EU parliament defined the mandatory energy and environmental targets that the EU must meet by 2020 as follows: (1) to reduce emissions of greenhouse gases by 20 % by 2020, taking 1990 emissions as the reference; (2) to increase energy efficiency to save 20 % of the EU's energy consumption by 2020; (3) to achieve 20 % renewable energy within total energy consumption in the EU by 2020; and (4) to achieve 10 % bio fuels energy within the total consumption by vehicles by 2020. As such, energy standardization is drawing more and more attention from EU countries.

According to the way the E.U. emissions reduction plan operates, E.U. member countries issue permits granting certain emission credits to companies. These companies can only emit greenhouse gases within the credits; otherwise they are deemed illegal (Lv 2000). Companies that fail to stay within the emissions credits can buy spare credits from those that over-fulfill their reduction targets through the emissions trading scheme, or help developing countries implement clean development mechanisms (CDM) or plant trees in exchange for extra credits (Zhou 2007).

4.2.3.2 Japan's Energy Conservation and Emissions Reduction Policy

As one of the countries with the most significant global warming characteristics, Japan has long attached great importance to energy conservation and emissions

[3] Data source: Shi Hongxiu, Energy Savings and Emissions Reduction Strategies of the E.U.at www.chinareform.org.cn/cirdbbs/edevelopment/ 2007/10/17/17160.html,

reductions. First, it keeps scaling up its investment in the research and development of energy conservation and emissions reduction technologies. The budget of the Ministry of Economy, Trade and Industry for the development of energy conservation and emissions reduction technologies was raised from 4.5 billion yen in 2002 to 50.2 billion yen in 2007, representing an average annual increase of 62.0 %. As a result, Japan's technological innovation competence in this regard is constantly enhanced.

Second, it improves relevant laws, regulations and standards. As early as 1979, Japan made and enforced the *Energy Utilization Reasonability Law*, which stipulated that the government is entitled to provide guidance and advice on energy conservation for business owners, and specified regulations for high energy-consuming sectors such as construction and machinery. In the *Energy Conservation Law* revised in 1988, Japan began to enforce the Top Runner standard, requiring that the energy conservation and emissions reduction performances of automobiles, household appliances and other machinery and equipment should surpass that of similar products which are commercially available.

4.2.3.3 International Carbon Trading Mechanisms

Currently, there are three major carbon trading mechanisms. (1) The Clean Development Mechanism (CDM). Article 12 of the *Kyoto Protocol*, which became effective in February of 2005, stipulated a market-based, flexible and win-win mechanism. The core content includes: (1) to allow Annex 1 countries (industrialized countries with binding reductions obligations and targets) to cooperate with non-Annex 1 countries (voluntary developing countries without binding reductions obligations), helping the latter implement clean development mechanisms, and to allow the latter to sell Certified Emissions Reductions (CERs) as valuable assets to the former so as to lower the total economic costs of achieving global greenhouse gas emissions; (2) Joint Implementation (JI). This principle is defined in Article 4 and Article 6 of the *Kyoto Protocol*. Developed countries may transfer to, or acquire from, any other developed countries' emissions reduction units (ERUs)[4] resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy. The ERUs obtained by one developed country can be transferred to another signatory developed country, and an equivalent credit is deducted from the total credit assigned to the transferor. (3) Emissions Trading (ET). This mechanism is defined in Article 17 of the *Kyoto Protocol*. Developed countries can transfer to each other part of their Assigned Amount Units (AAUs).

[4] According to international practice, each ton of CO_2 removed from the atmosphere is equal to one carbon credit. One ton of CO_2 emissions reductions will bring an equivalent carbon credit.

4.3 Breakdown of Basics Elements of Environmental Capacity Control, Energy Conservation and Emissions Reductions Targets

The basic environmental elements, i.e. water, soil and atmosphere, constitute the basic elements in environmental capacity, which provides environmental water capacity, environmental soil capacity and environmental atmosphere capacity for human life in its economic and social development aspects. When forests, grasslands and other carbon sequestration ecosystems (the targets of the main pollutant controls)are not taken into consideration, energy conservation and emissions reductions can by broken down by basic environmental elements.

Total control is based on the size of the environmental capacity, particularly the size of the water, soil, and atmosphere capacity. An econometric model has been developed abroad to estimate the relations among atmosphere pollution, water pollution and economic development in certain regions and even around the world. This model provides a reference for the determination of environmental capacities. It requires a lot of environmental monitoring data, and it is quite challenging to determine the total control target.

4.3.1 Environmental Water Capacity and Main Pollutant Control, and Energy Conservation and Emissions Reduction Targets

The premises for determining environmental water capacity include: (1) specific water areas and hydrologic conditions; (2) specific pollutant discharge method and water quality target. Under these two premises, the environmental water capacity is the maximum allowable pollution load of water body per unit of time. The capacity calculation is the inversion of the concentration calculation. When the concentration of a control point hits the given target, the discharge of pollutants equals the environmental water capacity.[5] For China, the primary control targets of environmental water capacity are the total COD and emissions reduction targets.

According to the *Notice of the State Council on Issuing a Comprehensive Work Plan on Energy Conservation and Emissions Reductions (Guo Fa [2007] No. 15)*, the COD should be reduced from 14.14 million tons in 2005 to 12.73 million tons by 2010. To achieve this total control and emissions reduction target, we should first assess the environmental water function zone by county, investigate the pollution sources in all function zones, assess the water quality and calculate the

[5] Yi yang City Environmental Protection Bureau: Verification and Analysis Report on Environmental Capacity of Yi yang City, July of 2014.

capacity, and then use the result as the basis by which to distribute the total control target.

4.3.2 Environmental Soil Capacity and Main Pollutant Control, and Energy Conservation and Emissions Reductions Targets

Environmental soil capacity is more complicated to determine, as it is prone to pollution from irrigation water, underground water and is affected by solid waste. In recent years, farmland along roads has been severely contaminated by lead and other heavy metals in exhausted gases emitted by vehicles. According to the *Environmental Quality Standard for Soils (GB15618-1995)*, the soil environmental quality can be rated Grade-I, Grade-II and Grade-III, respectively, corresponding to Class-I, Class-II and Class-III standards. First, a county-specific environmental soil function zone survey should be conducted. Then the environmental quality standards should be analyzed according to soil sampling, and the contents of heavy metals, including cadmium, mercury, copper, lead, zinc, nickel and chromium and the content of arsenic, HCH and DDT in different function zones should be monitored. After that, the differences between actual content and the environmental soil quality standards should be analyzed and then used as the basis for the total control of environmental soil capacity to provide a solution on whether to allocate and how to allocate.

4.3.3 Environmental Atmosphere Capacity and Main Pollutant Control, and Energy Conservation and Emissions Reduction Targets

Environmental atmosphere capacity refers to the total amount of pollutants that can be emitted into the atmosphere without harming people's health. To control pollution, we must first find out the relationship between emissions and atmosphere quality standards,[6] and adopt the atmosphere quality standards that can protect people's health. Then we must determine the environmental atmosphere capacity of each area according to the atmosphere quality standards. After that, we should conduct a survey on non-point source pollution and point source pollution to find out the relationship between the emissions of main pollutants in different regions and the environmental atmosphere capacity (surplus or deficit) so as to provide a

[6] The atmosphere diffusion model can help define the relations between emissions and atmosphere quality.

reference for allocating total emissions among different regions. Once the maximum total emissions that comply with the local atmosphere quality standards of each region are determined, the allowable total emissions can be allocated among different emission sources.

Although the environmental monitoring data from 60 medium and large cities across China indicates that air quality shows signs of improvement in most cities, with the content of SO_2 in the air dropping in 50 cities, emissions of SO_2 remain the core target of major pollutant emissions totals and emissions reductions in China. According to the *Notice of the State Council on Issuing the Comprehensive Work Plan on Energy Conservation and Emissions Reductions (Guo Fa [2007] No. 15)*, the total emissions of SO_2 should be reduced from 25.49 million tons in 2005 to 22.95 million tons by 2010. This provides a specific action plan for using the atmosphere capacity and controlling the total amount of main pollutants. However, such control targets need to be allocated among different regions according to the atmosphere standards.

4.4 Framework Proposals for Future Legal Actions

On the basis of leveraging the theory on the right to use environmental capacity, and summarizing the experience in energy conservation and emissions reductions, we can break down the basic elements of environmental capacity control, energy conservation and emissions reduction targets. However, this requires further legal actions in order to provide framework support.

4.4.1 The Significance of Establishing the Right to Use Environmental Capacity

The use of environmental capacity may give rise to a series of legal relations, which should, like other environment or resource-related legal relations, fall under the premise of existing environment and resource laws and regulations. Legal relations won't be derived without corresponding laws and regulations. Although there is no specific law on the right to use environmental capacity, the *Law on Environmental Protection*, the *Law on the Prevention and Control of Water Pollution*, the *Law on the Prevention and Control of Environmental Pollution Caused by Solid Waste*, the *Law on the Prevention and Control of Air Pollution* and other existing environment- and resource-related laws already contain relevant legal relations. For instance, in practice, on top of the *Law on Environmental Protection*, the *Law on the Prevention and Control of Water Pollution*, a watershed-specific pilot project has been launched on emissions trading which conforms to the right to use environmental capacity. Also, in the pilot program to develop a circular economy and build a resource-conserving and environmentally-friendly society in the Binhai New Area, the city of Tianjin launched the first state-level emissions trading market and improved the mechanism for the total control of main pollutants.[7]

It is well-known that since China kicked off its reform and opening-up drive, the country's economy has been decentralized. Particularly since the fiscal decentralization, local governments have become the major drivers of economic growth. The conflict between regional economic growth and environmental protection has long been a problem. The driving motive of regional economic development and the restricting motive of environmental protections conflict with each other. The conflict between motives can be addressed through legislation which can legalize the right to use environmental capacity to provide long-term stable expectations for energy conservation and emissions reductions.

4.4.2 Legal Relations on the Right to Use Environmental Capacity and Adjustment Framework

Water, soil and atmosphere are basic environmental elements. Accordingly, the legal relations around the right to use environmental capacity include the legal relations around the right to use water, soil and atmosphere capacity. Therefore, the objects regulated by the legal relations around the right to use the environmental capacity respectively include the right to use water, soil and atmosphere capacity. They are used to regulate the relations arising from people's use of environmental capacity, giving rise to the legal rights of using environmental capacity and the legal responsibilities of protecting the environment.

The legal relations around the right to use environmental capacity, like other legal relations, will undergo a process of birth, alteration and elimination. In this process, two very important links are a quota: initial acquisition – and trading – and re-allocation.

(1) Quota – initial acquisition. Local governments and enterprises get their emissions quotas by breaking down the environmental capacity and total emissions control targets. This is the right to use the environment as initially acquired by local governments and enterprises. (2) Trading – re-allocation. The right to use environmental capacity initially acquired by local governments and enterprises can be transferred and traded, which is conducive to total control and effective resource allocation. When the total local emissions are lower than the environmental capacity, and a scientific and reasonable emissions quota allocation system is adopted, necessary conditions for establishing a trading market for the right to use environmental capacity are in place.

[7] According to a report released on www.ditan360.com, the first state-level emissions trading exchange was established in Tianjin on September 25 of 2008.

The main direction for legal relations adjustment in the future is as follows: to improve laws and policies conducive to energy and resource conservation and environmental protection, and enhance the prevention and control of water, soil and atmosphere pollution; fairly and reasonably solve the issue of emissions quota allocations through legislation, define the subject of the right to use environmental capacity, and lay a foundation of property rights for inter- and intra-region, -industry and -watershed trading of the right to use environmental capacity; specify the application scope for the right to use environmental capacity through legislation and define region-, industry- and watershed-specific market players so as to provide rules for establishing and improving the trading market for the right to use environmental capacity; implement the energy conservation and reduction policies in project approval, construction and production through legislation on energy conservation, clean production and circular economy.

4.4.3 Derivative Legal Relations and Policy Adjustment Framework

4.4.3.1 Adjust Element Prices to Establish a Pricing Mechanism Conducive to Energy Conservation and Emissions Reductions

Legal relations around the right to use environmental capacity involve water, soil, atmosphere and other basic environmental resource elements. If the prices of energy, land and other resource elements are distorted, economic growth will come at an excessive resource cost. To adjust the legal relations around the right to use environmental capacity, implement energy conservation and emissions reduction policies, and build a resource-conserving and environmentally-friendly society, we must establish and improve upon a compensatory resource use system and on an ecological environment compensation mechanism, improve the pricing mechanism for production factors and resources that can reflect the relations between supply and demand on the market, and limit resource scarcity and environmental damage costs.

4.4.3.2 Combine Industrial, Credit and Taxation Policies to Build an Incentivizing and Restriction Mechanism for Energy Conservation and Emissions Reductions

We should guide industrial restructuring toward energy conservation and emissions reductions through industrial policies, strictly control new energy-intensive and highly-polluting projects, raise market access thresholds of energy conservation and environmental protection, encourage integrated utilization of resources, recycling of garbage and clean production, and advance the circular economy. We should also use credit policies to leverage the price discovery function of the market to guide different economic subject interests which in turn boost energy conservation and emissions reductions. On top of that, we should provide preferential taxation policies for energy-efficient and less-polluting industries, impose fines or increase taxes on energy-intensive and highly-polluting industries, and encourage the innovation of advanced and applicable conserving, substituting and recycling technologies. Moreover, we should link the environmental protection credit standings of enterprises to credit and taxation policies, and facilitate the establishment of an environmental enterprise protection credit system through preferential credit and taxation policies.

4.4.3.3 Local Support and Legal Responsibilities

The support of local governments is key to the success of energy conservation and emissions reductions. The allocation of binding energy conservation and emissions reduction targets based on assessments of regional economic development benefits can protect the enthusiasm of local governments for economic development, promote local energy conservation and environmental protection initiatives, and enhance local competence to cope with climate changes and implement this basic national policy. Moreover, we should break down energy conservation and emissions reduction targets into long-term legal responsibilities for local governments, and, in a traditional but effective manner, render local governments at various levels responsible for energy conservation and emissions reductions in their respective administrative areas.

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Chapter 5
Calculations and Analysis of the Contributions of Industrial Structure Transition to Sustainable Development – A Case Study of Fujian Province

Lin Qing, Chen Xu, and Wang Ying

Sustainable development requires that human economic growth does not come at the price of environmental destruction. The connotation of sustainability has two fundamental aspects, development and sustainability. Without development, there can be no sustainability. If we focus on development without considering sustainability, long-term development will be groundless. Sustainable development mainly involves two aspects, sustainable economic development, and sustainable resource and ecological development. Sustainable development is based on sustainable resource utilization and a good ecological environment, and on sustainable economic development. Since 1992, when the United Nations Conference on Environment and Development adopted it as a common development strategy in the twenty-first century, sustainable development has become a global action plan.

As the concept of sustainable development developed, people gradually realized that industrial structure transition and sustainable development are inseparable. Industrial structure transition is often associated with economic growth, and the intensive growth effect of industrial structure transition implies sustainable development. Therefore, industrial structure transition theoretically can contribute to sustainable development. But empirically this contribution is rarely calculated. In this paper we will, taking Fujian Province as an example, calculate the contribution of industrial structure transition to sustainable development.

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5.1 The Theoretical Explanation of the Contribution of Industrial Structure Transition to Sustainable Development

5.1.1 Industrial Structure Transition Is an Important Independent Source of Economic Growth

Industrial structure transition is inseparable from economic growth. According to the neoclassical growth theory, economic growth results from the long-term effects of capital accumulation, labor increases and technological progress under competitive conditions of balance. But according to the view of structuralism, structural changes normally occur under conditions of imbalance, and economic growth is just an aspect of production structure changes. For instance, Whitman Rostow (1963) argued that economic growth is in essence the process of a sector, and that the growth sequence is not only a motion of the total, but a sequence which culminates in a number of sectors and successively associates with leading sectors. The empirical study of H. Chenery (1986) and his peers further unveiled the relations between industrial structure transition and economic growth, arguing that economic growth is only one aspect of industrial structure transition, and that the move of labor and capital from less productive sectors to more productive factors in developing countries where the marginal productivity of production factors is unequal and imbalanced can accelerate economic growth. Angus Maddison (1996) also, in a longer time sequence and range, proved that structural transition is an important independent source of growth.

5.1.2 Industrial Structure Is Correlated with the Sustainable Development of Resources and Ecological Environment

This is mainly because of significant differences in the resource consumption and environmental impacts of various industries. Hong Yinxing (2000) conducted research on the energy consumption of three industries in 1997. When energy consumption per every turnover of 10,000 yuan was used to indicate the energy consumption intensity of various industries, the first, secondary and tertiary industries respectively consumed 0.416 tons, 2.720 tons and 0.636 tons. When energy was measured with 10,000 tons of SCE, the first, secondary and tertiary industries respectively consumed 59.05 million tons, 1.01259 billion tons and 146.40 million tons of SCE, accounting for 4.03 %, 73.3 % and 10.6 % of the total. This shows that the energy consumption intensity and volume of the secondary industry is far greater than that of the first and tertiary industries. The three industries also vary significantly in their impacts on environmental quality through waste discharge and emissions. Wang Huijiong (1999) conducted an empirical analysis of the total discharge and emissions of waste water, gas and solids by various industries in different years, finding that waste from industry accounts for the largest part of total discharge and emissions of waste water, gas and solids. The basic industry is characterized by large resource consumption volume, high consumption intensity, and a strong reliance on resources.

In terms of the environmental impact of various industries, Xue Jinjun (2005) argued that compared with the first and tertiary industries, the secondary industry develops natural resources at a significantly higher intensity, and discharges and emits a much larger volume of waste into the environment. Amongst them, air pollution and water pollution are the outstanding environmental problems arising from the process of industrialization. Sanford Grossman and David O'Connor (2003) proposed a model for changes in economic development patterns and industrial structure in East Asia, dividing the evolution of industrial development and environmental pollution into three stages: (1) The stage of light industry which focused on the production of labor-intensive products. At this stage, textiles, clothing, food and beverages and other light industries were prioritized, and their pollution intensity was quite low. (2) The stage of heavy industry which focused on the production of resource-intensive products. Non-metallic minerals and manufacturing products, ferrous metal smelting and manufacturing products, and petrochemical and other intermediary products were developed rapidly. In this process, they caused much more intense pollution. At this stage, air pollution became a serious environmental problem, and poisoning caused by toxic chemical materials and heavy metals became increasingly severe. (3) The stage of electronic industry which focused on the production of capital and technology-intensive products. At this stage, dominant sectors switched to electronics, electronic machinery, ordinary machines and transport machines. Pollution was somewhat alleviated, and the major problem was the management of toxic wastes.

The studies of most scholars indicate that secondary industry is highly reliant on resources and energy, and causes the most severe environmental pollution. The excessive output of secondary industry materials is likely to cause overuse of resources and severe environmental destruction. The tertiary industry has a much smaller resource consumption intensity and causes much less pollution in the environment. A high proportion of the tertiary industry is conducive to regional sustainable development. The first industry is highly reliant on land resources. A severe shortage of land resources will cause a serious surplus of labor in the countryside, which is a serious waste of resources. This does not conform to the optimal resource utilization required by sustainable development.

5.1.3 The Intensive Growth Effect of Structural Evolution Can Boost Sustainable Development

The mechanism in which industrial structure transition boosts rapid and sustained economic growth is different from the mechanism in which overall economic efficiency is boosted by increasing sector-specific productivity through technological progress and endogenous economic growth. Industrial structure transition increases the average productivity of the whole society by moving production factors from less productive sectors to more productive sectors to balance the productivity of factors in different sectors.

Industrial structure transition, i.e. resource re-distribution in different industrial sectors, achieves economic growth by increasing the efficiency of production factors, which is different from attaining extensive economic growth by increasing the input of production factors. Therefore, industrial structure transition will present a growth effect, and, more specifically, an intensive growth effect. To achieve sustainable development under the restrictions of resources and environment, people must increase the utilization efficiency of production factors and embark on a road of intensive growth. The intrinsic mechanism itself in which the industrial structure transition boosts economic growth implies sustainable development.

5.2 Construction of the Contribution Calculation Model

5.2.1 Analytical Approach

Sustainable development includes three basic requirements: to constantly increase economic efficiency, to contain ecological degradation and control environmental pollution, and to conserve resources for the sustainability of natural resources. As such, the contribution of industrial structure transition to sustainable development is mainly measured by the contribution of the industrial structure to economic growth, the contribution of industrial structure transition to the control of resource consumption and the control of the environment.

First, the Moore structural change value can be leveraged to build a coefficient of industrial structure transition and get the structural transitions of various industries in the entire economic system. The ratio of the regional GDP rate, energy consumption intensity decrease rate, and the environmental pollution intensity rate of change to the coefficient of industrial structure transition respectively represents the contribution of each degree of industrial structure transition to economic growth, the control of resource consumption and the control of the environment.

5.2.2 *Construction of the Coefficient of Industrial Structure Transition*

The coefficient of industrial structure transition is calculated with the space vector method. Based on the space vector angle, the industry is divided into n sectors to form a group of n dimensional vectors. When the proportion of a sector in the national economy changes, the angle between it and other industries (vectors) will change accordingly. By adding up all angle changes, we can get the structural changes of all industries in the whole economic system.

The angle between two groups of vectors in two periods is used as an indicator for industrial structural change, and this indicator is called the Moore structural change value. The formula is as follows:

$$M_t^+ = \frac{\sum_{i=1}^{n} W_{i,t-1} * W_{i,t}}{\sqrt{\sum_{i=1}^{n} W_{i,t-1}^2 * \sum_{i=1}^{n} W_{i,t}^2}}$$

M_t^+ stands for the Moore structural change value, $W_{i,t-1}$ for the proportion of industry i in period $t - 1$, and $W_{i,t}$ for the proportion of industry i in period t.

The total angle that defines the changes between vectors (proportions of industries) is the coefficient of industrial structure transition, which is represented by θ. Thus $\theta = \arccos M_t^+$, where the higher the θ is, the larger the industrial structure transition rate is.

5.3 Calculation of the Contribution of Industrial Structure Transition to Sustainable Development in Fujian Province

5.3.1 *Calculation of Coefficient of Industrial Structure Transition*

The key to calculating θ– the coefficient of industrial structure transition – is sector division and period. According to the division method used in the statistical yearbooks of Fujian Province, we will divide the sectors engaged in material production into the first industry, the second industry and the tertiary industry. The first industry mainly consists of farming, forestry, animal husbandry and fishery. The second industry can be divided into industry and construction. The tertiary industry is comprised of transport, storage, post and telecommunications, wholesaling and retailing, finance and insurance, real estate and other service sectors. As such, the national economy can be divided into the following eight

Table 5.1 Composition of regional GDP in major years Unit: %

Year	Farming, forestry, animal husbandry and fisheries	Industry	Construction	Transport, storage, post and telecommunications	Wholesaling and retailing	Finance and insurance	Real estate	Other services
2000	16.34	37.5	6.15	11.33	9.8	4.79	3.01	11.08
2002	14.2	40.21	5.92	10.49	9.49	4.87	3.02	11.48
2004	13.01	41.84	6.9	9.94	9.24	4.83	3.04	11.79
2006	11.77	43.49	5.67	7.05	8.77	3.02	3.02	11.69

Source: Calculated according to the statistical yearbooks of Fujian Province

Table 5.2 Coefficient of industrial structure transition of Fujian Province in 2000–2002, 2002–2004 and 2004–2006

Period	2000–2002	2002–2004	2004–2006
Coefficient of industrial structure transition (degree)	4.11	2.49	4.97

Unit: Degree

sectors: (1) farming, forestry, animal husbandry and fisheries; (2) industry; (3) construction; (4) transport, storage, post and telecommunications; (5) wholesaling and retailing; (6) finance and insurance; (7) real estate; and (8) other services. With regard to the period, for simplicity and good effect, and in view of data availability, a period of 3 years is selected in this paper.

Therefore we can calculate the coefficient of the industrial structure transition of Fujian Province in three periods, i.e. 2000–2002, 2002–2004 and 2004–2006 according to data in Table 5.1 and the formula of Moore's structural change value. Table 5.2 demonstrates the calculation results. From Table 5.2, we can see that the coefficient of industrial structure transition displayed an increasing fluctuation between 2000 and 2006. The period 2004–2006 reported the largest industrial structure transition, 4.97 degrees.

5.3.2 Calculation of Contribution of Industrial Structure Transition to Economic Growth

The GDP growth rate of Fujian Province can be used to characterize the economic growth in the province. Therefore, the contribution of each degree of industrial structure transition to regional GDP growth can be calculated by combining the coefficient of industrial structure transition (θ) in the three periods and the GDP growth rate of Fujian Province.

From Table 5.3 we can see that each degree of industrial structure transition contributed the most to economic growth in the period 2002–2004, and that this contribution first climbed and then dropped between 2000 and 2006, but remained positive in each period. This shows that the industrial structure in Fujian Province changed in a direction conducive to economic growth throughout whole period.

5.3.3 Calculation of the Contribution of Industrial Structure Transition to the Control of Resource Consumption

The depletion of natural resources studied in sustainable development mainly refers to the depletion of non-renewable resources, especially oil, coal and natural gas. As a result, the depletion of resources can be approximately substituted with the depletion of energy. Although such a substitution is rough, it doesn't affect the

Table 5.3 Contribution of industrial structure transition to regional GDP growth

Period	2000–2002	2002–2004	2004–2006
Coefficient of industrial structure transition (degree)	4.11	2.49	4.97
Regional GDP growth rate (%)	19.7	24.65	28.16
Contribution of each degree of industrial structure transition to regional GDP growth (%)	4.8	9.9	5.67

Source: Calculated according to the statistical yearbooks of Fujian Province

Table 5.4 Energy consumption and intensity

Year	2000	2002	2004	2006
Total energy consumption (10,000 tons of SCE)	2942.6	3489.89	4527.8	6840.28
Energy consumption intensity (10,000 tons of SCE per unit GDP)	0.4423	0.4382	0.4561	0.5376

Source: Calculated according to the statistical yearbooks of Fujian Province

Table 5.5 Contribution of industrial structure transition to the control of energy consumption

Period	2000–2002	2002–2004	2004–2006
Coefficient of industrial structure transition (degree)	4.11	2.49	4.97
Energy consumption intensity decrease rate (%)	0.93	−4.08	−17.87
Contribution of each degree of industrial structure transition to the control of resource consumption (%)	0.23	−1.64	−3.60

Source: Calculated according to the statistical yearbooks of Fujian Province

result of the analysis. In this paper, energy consumption intensity is adopted as a calculation index (the consumption of energy in 10,000 tons of SCE per unit of regional GDP. In view of the impact of price index changes, the data for regional GDP used in this paper is a total output index with 1952 as the base period, i.e. the total output of 1952 was 100 units). The ratio of the energy consumption decrease rate of Fujian Province to θ is the contribution of industrial structure transition to the control of energy consumption in the period between (t − 1) and t. Within a given period, if the ratio increases, it means that the industrial structure transition is in a direction conducive to the control of energy consumption. But if the ratio decreases, it means that the industrial structure transition is in a direction adverse to the control of energy consumption. The detailed data and analysis are as follows (Tables 5.4 and 5.5):

The calculation indicates that the energy consumption intensity of Fujian Province was fluctuating upward between 2000 and 2006, implying that the economic growth of the province was still accompanied by increasing resource input. During this period, the contribution of each degree of industrial structure transition to the control of resource consumption was falling. The period 2002–2006 even reported a negative contribution. On the whole, the industrial structure of Fujian Province didn’t change in a direction conducive to the sustainable development of resources, nor facilitate low input and high output growth. Therefore, great effort should be made to change the situation.

5.3.4 Calculation of the Contribution of Structural Transition to the Control of the Environment in Fujian Province

Environmental pollution mainly consists of three parts: waste gas, waste water and waste solids. But according to the source, it mainly includes domestic pollution and industrial pollution. Industrial restructuring falls under the scope of production. To study the impact of industrial restructuring on the control of the environment, we can use the total industrial waste water, gas and solids per unit of regional GDP as an accounting index, taking the regional GDP data of 1952 as a benchmark, and apply the environmental pollution intensity (i.e. the amount of industrial waste water, gas and solids per unit of regional GDP) to get the contribution of industrial structure transition to the control of the environment: the ratio of the environmental pollution decrease rate to θ is the contribution of industrial structure transition to the control of ecological environment in the period between $t - 1$ and t. In the selected period, if the ratio increases, it means that the industrial structure is shifting in a direction beneficial to controlling industrial waste. If the ratio decreases, it means that the industrial structure is shifting in a direction adverse to controlling the industrial wastes. The detailed information and analysis are as follows:

From Table 5.6, we can see that the total emissions volume and intensity of industrial waste gas in Fujian Province was on the rise in 2000–2006, the discharge volume of industrial waste water was increasing while the discharge intensity was fluctuating upward, and industrial waste solids were also fluctuating upward, though intensity was fluctuating downward. Table 5.7 shows that the contribution of industrial structure transition in Fujian Province to the control of waste water, gas and solids discharge and emissions intensity wasn't stable, but was fluctuating significantly. In 2000–2002, the contribution of each degree of industrial structure transition to the control of waste water, gas and solids discharge and emissions intensity was negative. In 2002–2004, the contribution of each degree of industrial structure transition to the waste water control and waste gas control was still negative and declining dramatically. But the contribution of each degree of industrial structure transition to the control of waste solids was significantly increased to a positive value. In 2004–2006, the contribution of each degree of industrial structure transition to waste water control was positive, but its contribution to waste gas control was negative and presented a significant rise compared with the previous period. Its contribution to the control of waste solids was positive, but the contribution was on the decline compared with the previous period. Holistically, the industrial structure of Fujian Province moved in a direction beneficial to the control of ecological environment.

Table 5.6 Discharge and emission of waste water, gas and solid

Year	Discharge of waste water (10,000 tons)	Intensity of waste water (10,000 tons per unit GDP)	Emissions of waste gas (100 million standard cubic meters)	Intensity of waste gas (100 million standard cubic meters per unit GDP)	Generation of waste solids (10,000 tons)	Intensity of waste solids (10,000 tons per unit GDP)
2000	57617.00	8.66	2828.00	0.43	2191.00	0.33
2002	78510.79	9.86	3564.60	0.45	4130.96	0.52
2004	115227.5	11.61	5020.23	0.51	3361.22	0.34
2006	127583.41	10.03	6883.77	0.54	4237.54	0.33

Source: Calculated according to the statistical yearbooks of China and Fujian Province

Table 5.7 Contribution of structural transition to the control of the ecological environment

Period	2000–2002	2002–2004	2004–2006
Coefficient of industrial structure transition (degree)	4.11	2.49	4.97
Waste water intensity decrease rate (%)	−13.86	−17.75	13.61
Contribution of each degree of industrial structure transition to the control of waste water (%)	−3.37	−7.13	2.74
Waste gas intensity decrease rate (%)	−4.65	−13.33	−5.88
Contribution of each degree of industrial structure transition to the control of waste gas (%)	−1.13	−5.35	−1.18
Waste solids intensity decrease rate (%)	−57.58	34.62	2.94
Contribution of each degree of industrial structure transition to the control of waste solids (%)	−14.01	13.90	0.59

Source: Calculated according to the statistical yearbooks of China and Fujian Province

5.4 Conclusion

By calculating the contribution of each degree of industrial structure transition to economic growth, the control of resource consumption and the control of ecological environment, we can draw a conclusion as follows: the industrial structure transition was in a direction conducive to economic growth in 2000–2006 in Fujian Province. But the control of energy consumption didn't meet the target, evolve toward resource sustainability, or achieve a result of low input and high output. The control of waste water, gas and solids discharge and emissions was not stable enough, undergoing significant fluctuation, and didn't contribute much to the sustainable development of ecological environment. Therefore, during industrial structure transition, more attention should be paid to guiding the direction of industrial restructuring so that its transition can promote resource and ecological sustainability while boosting economic growth.

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Chapter 6
Construction of Theoretical Framework for Innovations in Green Agriculture and Practical Exploration

Yan Lidong, Deng Yuanjian, and Qu Zhiguang

In the report he delivered at the 17th CPC National Congress, then Chinese President Hu Jintao said that we should "promote a conservation culture by basically forming an energy- and resource-efficient and environment-friendly structure of industries, pattern of growth and mode of consumption." He also emphasized that we should deeply establish awareness of conservation in the whole of society. The report introduced the concept of ecological civilization for the first time. This represented a sublimation of the CPC's conception of scientific development and harmonious development. Development is the key to building a concept of ecological civilization, developing a green agriculture, making an overall plan for urban and rural socio-economic development, and building a new ecological socialist countryside. The essence of development is to increase productivity, promote the reasonable distribution of rural productivity, optimize the allocation of factors and maximize economic benefits. To build a new socialist countryside, we must ensure harmony among politics, economy, society, culture, nature and ecology.

China is a developing country characterized by a large agricultural population, a relative shortage in resources, continuous ecological degradation and severe environmental problems. The construction of an innovation system for green agriculture, the study and practice of green agriculture theories, and the application of new agricultural development patterns and new management concepts to promote agricultural modernization and increase the competitiveness of agricultural products

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are an important part of realizing the people-oriented scientific outlook on development, building a new harmonious socialist countryside and facilitating the sustainable development of agriculture and rural economy. The theoretical study and practice of green agriculture provides powerful theoretical and technological support for the sustained and healthy development of the agricultural economy and even the whole national economy. It is bound to exert a profound impact on sustainable economic development and social progress.

6.1 The Construction of a Green Agriculture Theory System Marks a Substantive Leap in Innovation for Agricultural Theories

Green agriculture is an agricultural development pattern featuring coordination between ecology, production and the economy for the comprehensive, coordinated and sustainable development of human society and the economy, which applies advanced technologies, industrial equipment and management concepts to boost the harmonious unity between product security, ecological security, resource security and the improvement of comprehensive agricultural economic benefits by advocating the standardization of agricultural products. The establishment of green agricultural theories represents a revolution in the history of agricultural development theories. Practice requires the guidance of theories. The establishment of green agricultural theories will position agricultural development at a deeper level, and provide a solid theoretical foundation for the development of China's agriculture in the twenty-first century. Currently, the development of green agriculture shows that a complete theoretical system has yet to be established, that the technical system, development pattern and key areas of green agriculture need to be further studied, demonstrated and theorized. The study of basic green agriculture theories will help break existing mindsets toward agricultural development, propose and demonstrate the basic scopes and principles unique to green agriculture, and build a green agriculture theory system with Chinese characteristics.

When conducting theoretical study and practical exploration for green agriculture, we think that the core of basic green agriculture theories mainly includes: the theory on ecological development, the theory on economic development, the theory on industrial management, the theory on marketing and trading, and the theory on organization and management. In the framework of green agriculture theories, the theory on ecological development is the foundation of the development of green agriculture, the theory on economic development is the ultimate goal of the development of green agriculture, and the theories on industrial management, marketing and trading, organization and management constitute the basic conditions and important guarantees of the development of green agriculture (See Fig. 6.1).

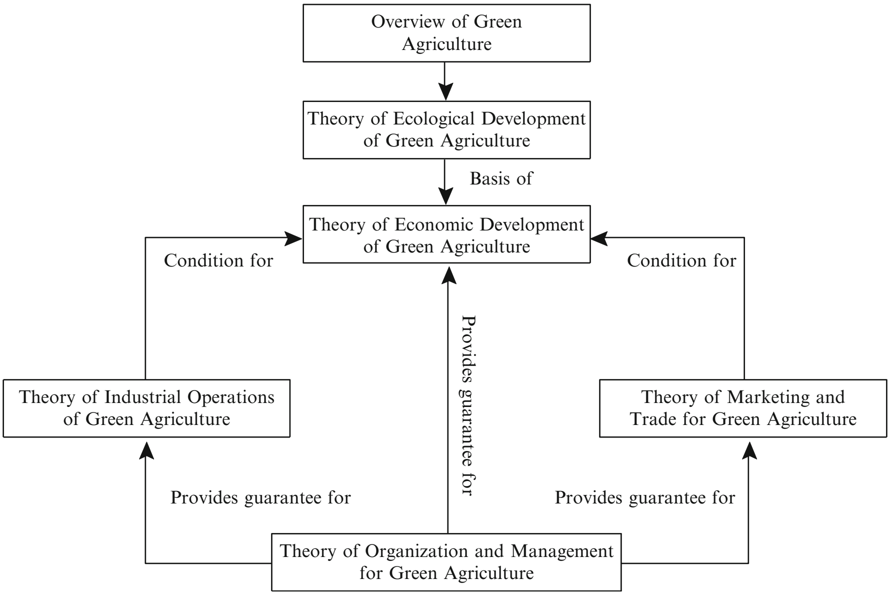

Fig. 6.1 Diagram of the green agriculture theory system

6.1.1 Theory on Ecological Development

This theory systematically explores the basic issues around the ecological development of green agriculture for the first time in China, fundamentally confirms the foundation of ecological theories for the sustainability of green agriculture, and unveils the mutual interaction between the development of green agriculture and ecological construction in the process of optimizing green agricultural ecosystems. It also addresses the impact of ecological destruction and environmental degradation of the sound operation and sustainable development of green agriculture so as to boost the sustained ecologically-friendly development of green agriculture and provide theoretical support for the research and demonstration of green agricultural technologies.

This theory mainly manifests issues regarding the ecological construction of green agriculture. It covers concepts of ecological civilization and green agricultural ecology, theories and methods of green agricultural ecology, compositions, forms, structures, functionality, types and features of green agricultural ecosystems, ecosystem services and optimizations for green agriculture, ecological balance for green agriculture, ecological benefit analysis for green agriculture, ecological evaluations for typical green agriculture demonstration areas, the protection of green agricultural ecosystems, the construction of an ecological safety index system for green agriculture, the maintenance of region-specific ecological safety, and the operation of ecological capital, ecological development targets and management approaches for green agriculture.

6.1.2 Theory on Economic Development

This theory systematically explores the basic issues around the development of green agricultural economy for the first time in China, fundamentally confirms the theoretical scope of green agriculture, including the operational mechanism and value orientation of a green agricultural economy, and unveils the mutual interaction between production, exchange, distribution and consumption in the process of natural reproduction and economic reproduction of green agriculture. This will provide a theoretical reference for us to improve the economic benefits of green agriculture, build a well-established theoretical system for the development of a green agricultural economy and incorporate green agriculture into China's macroeconomic development strategy system.

This theory mainly manifests issues pertaining to the production, exchange, distribution and consumption in the process of natural and economic reproduction of green agriculture. It covers the implication and essence of green agricultural economy, patterns and features of green agricultural economy, differences and relations between green agricultural economy and traditional agricultural economy, and the value orientation and externality analysis of green agriculture. It also reveals the operational form, mechanism and development pattern of a green agricultural economy, its infrastructure construction and technological innovation for green agriculture, evaluation system and flow analysis of a green agricultural economy, an economic evaluation of green agriculture demonstration areas, a supporting system for green agricultural economy, and a development outlook on and strategic approaches to green agricultural economy.

6.1.3 Theory on Industrial Management

This theory systematically explores the basic issues around the industrial management of green agriculture for the first time in China, fundamentally confirms that green agriculture is the dominant pattern in modern agriculture, unveils the laws of commercial, market-based and social operations of green agricultural products in the process of industrial management, reduces the trading links of green agricultural products, internalizes external transactions and reduces transaction costs so that the agricultural sector can grow efficiently, protect and improve the ecological environment and achieve the goal of agricultural sustainability.

This theory mainly manifests issues about the integrated operation of green agricultural industrialization. It covers the implication, background and significance of green agricultural industrialization, the industrialized development of green agricultural products, the construction of green agricultural demonstration areas and bases, the development of green agricultural industrialization and leading enterprises, organizational forms of green agricultural industrialization, intensive and large-scale operations of green agricultural industrialization, the distribution of green agricultural industrialization, the development patterns of regional green agricultural industrialization, the integration of green agricultural industrialization, approaches to green agricultural industrialization and guiding policies for green agricultural industrialization.

6.1.4 Theory on Marketing and Trading

This theory systematically explores basic issues concerning the marketing and trading of green agriculture for the first time in China, fundamentally establishes the consumption orientation of green agricultural products, unveils management concepts focusing on ecological construction and environmental protection, and the marketing concept, method and strategy underpinned by a green culture and centering on green consumption. It emphasizes the principle that green agriculture enterprises should combine their own interests, consumer interests and environmental interests. Accordingly, we should build a theoretical system of marketing and trading for green agriculture in line with the actual conditions of China so as to boost green and internationalized marketing and trading in the agricultural sector.

This theory mainly manifests issues regarding the marketing and trading to do with green agriculture. It covers the basic implications and fundamental principles of marketing and trade for green agriculture, the background behind green agricultural logistics, the overall assessment index system of green agricultural logistics, construction of green agricultural logistics parks, management of logistics and supply chains, marketing and trade standards for green agricultural products, the distribution system for green agricultural products, market system construction of green agricultural products, marketing channels and platform construction for green agricultural products, the international trade of green agricultural products, and the marketing and trading of policies of green agricultural products.

6.1.5 Theory on Organization and Management

This theory systematically explores basic issues pertaining to the organization and management of green agriculture for the first time in China and fundamentally establishes the concept of the organization and management for green agriculture. It unveils the important role that organization and management plays in the research and practice of green agriculture. Accordingly, we should, by standardizing green agricultural products, plan, control, organize, coordinate and lead every aspect of green agriculture to achieve the goal of sustainable green agriculture and facilitate the comprehensive, coordinated and sustained development of human society and the economy.

This theory mainly manifests issues pertaining to the guidance and management by management authorities of green agriculture. It covers the organization form, management objectives, systematic analysis, development plan, mode design, comprehensive assessment and performance management for green agriculture, quality monitoring and management of green agricultural products, quality and risk assessment of region-specific green agricultural products, the management of information systems for green agriculture, fiscal support policy for green agriculture, and the policy orientation and management mode of the government for green agriculture.

6.2 The Practical Function of Green Agriculture Research and Practice

6.2.1 The Pattern of Technology-Based Green Agricultural Production Is a Dominant Pattern in Modern Technology-Based Agricultural Production

The pattern of technology-based green agricultural production is a modern technology-enabled agricultural production pattern that leverages various resources and integrates advanced practical technologies by following a scientific outlook on development in accordance with the conditions of our country. It represents a new technological revolution in China's agricultural production. Focusing on efficiency rather than the speed of green economic development, the green agricultural production pattern ensures a virtuous cycle of agricultural ecological environment and optimizes a composite system structure of agriculture that consists of nature, economy and society so as to improve agricultural production technologies and the quality of agricultural industry, increase levels of irrigation, mechanization and information distribution, land output, resource utilization and agricultural labor productivity in agriculture, enhance overall agricultural production capacity, agricultural benefits and the competitiveness of agricultural products (Ge Bei 2004).

1. Guide the construction of agricultural infrastructure. By demonstrating and disseminating technologies and consolidating the construction of agricultural infrastructure, including farming facilities, energy recycling facilities, small agricultural implements, aquaculture installations, fresh-keeping facilities, and the green agricultural production pattern, we can enhance the capacity to develop green agriculture.
2. Guide the construction of stock breeds and the dissemination system. We should, on the principle of combining introduction, breeding, protection and development, focus on superior agriculture products when enhancing the innovation capacity for fine breeds, intensify the protection and utilization of high-quality resources, improve the cultivation, selection and introduction of fine breeds for farming and animal husbandry, advance the marketization process of stock

breeding and dissemination, and build a new stock breeding system fueled by government support and market force.

3. Guide the construction of a green agricultural technology innovation system. By experimenting, demonstrating and disseminating new green agricultural technologies, we can enhance our ability to train farmers in technology and to disseminate technology, rapidly disseminate green agricultural technology, provide strong support for sending green agricultural technology, and market information on green agricultural products and rural laws and policies to rural families in a consistent manner.
4. Guide the construction of a quality and safety program for green agricultural products. By demonstrating and disseminating new technologies, we can speed up the construction of a green agricultural standardization system, a quality inspection system for green agricultural products and demonstration bases for green agricultural production. We can also highlight key aspects, including environmental protection in producing areas, quality supervision of inputs, regulation of production specifications and market access control.
5. Guide the construction of a monitoring system for green agricultural resources and the ecological environment. The demonstration of and guidance on new technologies will play an important role in monitoring agricultural resources and the ecological environment, protecting endangered biological resources in ecologically vulnerable areas, preventing and controlling diffused pollution sources, preventing the spread of water pollution and invasive species, and improving the green agricultural production environment, as well as production and living conditions in rural areas.
6. Guide the construction of a green agricultural service and management system. We can, by collecting, saving and publishing green agricultural information, and highlighting nonprofit technical services, improve information distribution in agriculture, upgrade wholesale markets for agricultural products, build new green circulation patterns, facilitate the construction of a comprehensive law enforcement system in agriculture and guide the construction of a public green agricultural service platform.

6.2.2 The Important Role of Researching and Demonstrating Green Agriculture

Researching and demonstrating green agriculture will exert a profound impact on the development of the national economy. On top of absorbing the benefits from production patterns of traditional agriculture, ecological, organic and green agriculture integrates various agricultural production technologies to promote the coexistence of species, the circulation of materials and multilevel energy utilization within the ecosystem of green agriculture, and expands agricultural production in a reasonable manner according to local conditions. It solves problems arising from industrialization, including environmental pollution and ecological destruction, realizes coordinated development among the economy, resources and the environment, and advances the construction of a resource-conserving and environmentally-friendly society (Du Ping et al. 2006).

1. Enhance the security of agricultural products, ecology, resources, the economy and national defense. China is a developing country characterized by a high agricultural population, relative shortages in resources, continuous ecological degradation and severe environmental problems. According to incomplete statistics, China's consumption of pesticides is increasing by 10 % year by year. The large-scale use of chemical fertilizers, pesticides and plastic membranes in agriculture results in serious agricultural pollution. Therefore, the research on green agriculture is an inevitable choice for the sustained and steady development of modern agriculture in China. By developing and demonstrating green agriculture technologies, exploring new agricultural development patterns, applying new agricultural management concepts, and facilitating the upgrade and modernization of agriculture, we can solve the outstanding problems that bottleneck the development of agriculture, including a large population with relatively little arable land, shortages in energy, a fragile ecology, escalating environmental pollution, less competitiveness, and comprehensive productivity, to ensure a sound and sustainable development for green agriculture that aims for the security of agricultural products, ecology, resources, the economy and national defense (Lu Liangshu 2007).
2. Improve the competitiveness of agricultural products, and increase agricultural efficiency and farmers' incomes. By following a production pattern of green agriculture, we can utilize agricultural inputs in a scientific and reasonable manner, enhance the whole process of agricultural standards to ensure the quality and safety of agricultural products, and build up brand images of high-quality and safe agricultural products. On top of enhancing market access control and market order regulation, we can adopt a policy of high quality and high prices to improve the competitiveness of green agricultural products, boost the export of green agricultural products, and increase agricultural efficiency and farmers' incomes.
3. Advance the construction of a new socialist countryside. The research and demonstration of green agriculture sticks to the concrete objectives of a new socialist countryside –enhanced productive forces, higher living standards, civilized living styles, an orderly and clean environment, democratic administration– endows agricultural production, organization and management with "green" connotations, incorporates "green" requirements into the endogenous variables of agricultural production, controls pollution, protects the environment, strives for a harmonious development between men and nature, realizes a "green" transition for agriculture, and advances the construction of a new ecologically-friendly countryside.
4. Facilitate technological progress. By combining environmental control, pest management, cultivation, breeding, plantation and processing technologies in producing areas, we can build a system of green agricultural production

technologies adapted to regional characteristics, advance the research, demonstration and dissemination of production technologies, and increase the contribution of green agriculture to technological progress.

5. Fuel the growth of green GDP in the national economy. Green GDP can better embody the sustainability of the national economy and address problems of coordinated development among population, resources and the environment. A higher portion of green GDP in the GDP indicates a higher positive effect and a lower negative effect on national economic growth, and vice versa. Green agriculture can reduce the cost of agricultural production, improve the utilization of agricultural resources and increase the return per unit of agricultural products. The progress of green agriculture can significantly increase the contribution of the first industry to green GDP, increase the contribution of the secondary and tertiary industries to green GDP by extending the industrial chain, and boost the growth of green GDP in the national economy.

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Part II
Construction of Ecological Economy

Chapter 7
Thirty Years of Afforestation and Landscaping Reform in China

Zhu Junfeng

Some people have summarized the three-decade reform and opening-up course in China as follows: "The landscape is so beautiful across the country. The red flag is upheld while much progress is made. Time flies so fast and three decades have passed even before we notice it. The country is decorated with colorful flowers and green trees throughout the year." After three decades of reform and opening up, China is drawing the attention of the world with unprecedented dynamics and strong vitality. Three decades ago, a debate concerning the future of CPC and China, i.e. the debate on the proposition that practice is the sole criterion for testing truth, blew the horn of emancipating people's mind for reform and opening up. An ancient civilization with a history of thousands of years and a population of more than one billion embarked on a journey of building and advancing socialism with Chinese characteristics.

The forestry sector in China has faithfully carried out the guidelines and polices adopted by CPC since the Third Plenary Session of the Eleventh CPC Central Committee, closely followed the pace of reform and opening up, deepened the reform on forestry, adhered to a down-to-earth work style, blazed new trails in a pioneering spirit and implemented the scientific outlook on development, thus contributing significantly to China's modernization drive. Boosted by the strong impetus of reform and opening up, the forestry sector has made substantial progress. Particularly, the operating philosophy has undergone a transition to be ecology-focused to benefit society. Consequently, the sector has been highly valued by governments at all levels and the general public. The idea of nationwide afforestation and landscaping has taken deep roots in people's mind. As a result, the afforestation and landscaping drive has developed rapidly across China. A review of the three-decade reform and opening up course reveals three great

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feats, five major breakthroughs and three weak links in China's afforestation and landscaping undertaking.

7.1 Three Great Feats

7.1.1 The Nationwide Voluntary Tree-Planting Campaign Is the "Mobilization Order"

In 1981, upon the proposal of Comrade Deng Xiaoping, the Fourth Session of the Fifth National People's Congress adopted a resolution on December 13 to launch a nationwide voluntary tree-planting campaign. In Throughout the world's forestry history, it is rarely seen that a country would stipulate the obligation of tree-planting obligation for all its citizens through legislation to advance the rejuvenation of forest resources. So it can't be more remarkable in the world. As noted by world-renowned forestry expert Richard Becker, this move made of China will set an example for the whole world. The promulgation of this resolution ushered in a great upsurge in nationwide tree-planting. Comrade Deng Xiaoping not only advocated but also actively participated in tree-planting. He took part in the voluntary tree-planting campaign for 11 consecutive years from the China's first tree-planting day on March 12, 1979 till 1989. By 2008, the central leadership had joined the billion Chinese people in the nationwide tree-planting campaign for 30 consecutive years, which was destined to become a miracle of history. Fueled by the nationwide voluntary tree-planting campaign, afforestation and landscaping projects are seen in all parts of the country today. According to incomplete statistics, a total of over six billion people have taken part in voluntary tree-planting and planted more than 30 billion trees. If these trees were arranged at one-meter interval, they would be 750 times the length of the equator. This is a figure well worth the pride of the Chinese people. It is a long "green ribbon" presented by the Chinese nation to the world.

7.1.2 The "Green Great Wall" in China Is an "Apocalypse"

The year 1978 marked the initiation of a 73-year trans-century ecological project involving 551 counties of 13 North China provinces and covering a total area of 4.069 million square kilometers or approximately 42.4 % of the country's total area. Referred to as the "Green Great Wall", this project is the greatest of the world's four largest ecological projects. In 1978, when there was much to be done in China, such a magnificent and tough ecological project would undoubtedly challenge the material and financial resources, courage and will of a country and its people. The first-installment investment reached RMB 1.71 billion. Thirty years have passed since the kickoff of this project. The Three-North Shelterbelt Project, a series of human-planted windbreaking forest strips (shelterbelts) in North, Northeast and Northwest China designed to hold back the expansion of the Gobi Desert, made remarkable achievements. On the World Environment Day in 1987, the Three-North Shelterbelt Project management authority was recognized by the United Nations Environment Program (UNEP) as an excellent environmental protection organization. In 1988, 1994 and 1998, Lanzhou Institute of Desert Research, Shapotou of Ningxia and Naimanqi of Inner Mongolia were respectively recognized as members of the UNEP's Global 500 Roll of Honor for their fight against drought. The experience of the Three-North Shelterbelt Project can be regarded as an "apocalypse". Following its lead, a number of shelterbelt projects were launched along the Yangtze River, around the Taihang Mountains, along the Pearl River as well as in plains and coastal areas.

7.1.3 Conversion of Cultivated Land into Forests Is a New Milestone of Afforestation and Landscaping

Since ancient times, the reclamation of forests and grassland for grain production has been perfectly justified in China. From the exploitation of virgin land in border areas by troops during the reign of Emperor Wu of Han Dynasty to the present agricultural development, China has taken the reclamation of forests and grassland and the expansion of farmland as one of the important approaches to increase grain output. In 2000, the central government decided to increase the size of forests and grasslands at the expense of grain production, return farmland to forests and restore vegetation. This dramatic reversion represented a historic breakthrough in China's ecological environment construction, and a new turn for afforestation and landscaping. The initiative would require a total investment of RMB 430 billion over 16 years. In the first 8 years, 230 billion was spent. This project has the largest investment, the shortest duration, the best effect and is the most favored by the public. It drew wide attention from around the world and will exert far-reaching and profound influence.

7.2 Five Breakthroughs

7.2.1 Both the Quantity and Quality of Afforestation and Landscaping Have Been Improved

In 2007, the newly-afforested area reached 78 million *mu* (1 *mu* is approximately 666.7 square meters). The largest annual afforested area was more than 100 million *mu*. On average, two billion trees are planted every year. Consequently, the forest acreage was increased from 12 % three decades ago to 18.21 %. China's artificial forests make up a third of the world's total. According to the latest Global Forest Resources Assessment released by the United Nations, the world's forest area reduces by an average of approximately 100 million *mu* per year, whereas China's forest area increases by an average of 60 million *mu* per year, representing 53.2 % of the world's total annual average increase. This makes China the fastest country by forest increase. Due to technological progress and increasing investment, the quality of afforestation is improved. Since the kickoff of engineering-oriented and contractual afforestation, China has intensified the feasibility study, overall planning and project supervision. It has also adopted a series measures, including normalized management, payment after afforestation and intensified acceptance check. As a result, the afforestation survival rate and retention rate are significantly increased. Inspections carried out in recent years indicate that the survival rate and retention rate are well over 85 % and up to 95 %, and that the two rates are on the rise year by year.

7.2.2 Landscaping in Urban and Rural Areas and Sector-Specific Afforestation Is Developed Rapidly

Urban landscaping is an important part of China's afforestation and landscaping effort. Since the kickoff of reform and opening up, governments at all levels have attached great importance to urban landscaping as a window project, an image building project and a livelihood project. Landscaping has been gradually spread from medium- and large-sized cities to small towns and villages. Last year, Shanghai invested more than RMB two billion in urban landscaping, adding 12,000 mu of green space. Beijing accomplished the seven landscaping targets for a Green Olympics. Seven cities in China were listed among the National Forest Cities. Brought along by medium and large-sized cities and boosted by the new countryside initiative, landscaping in towns and villages are well received by the general public and valued by government leaders. The National Afforestation Committee awarded 100 counties, 990 villages and 9612 villages for their landscaping achievements. This presented a very good demonstration effect. Many sectors, including the road, railway, coal, oil, army and armed polices, have made unprecedented progress in landscaping. In 2007, the Ministry of Transport invested RMB 10.5 billion in road landscaping. So far, a total of 1.24 million kilometers of road is has been landscaped, accounting for 60.5 % of the nation's total. The coverage of green road projects is has been constantly extended.

7.2.3 Investment in Afforestation and Landscaping Is Increased

Since the kickoff of reform and opening up 30 years ago, the Chinese economy has sustained rapid and steady growth. The investment in afforestation and landscaping has increased year by year. Moreover, an array of preferential policies has been enacted, which has greatly mobilized people's enthusiasm for afforestation and landscaping. According to incomplete statistics:

– A total of RMB 83.2 billion has been invested since the Natural Forest Protection Project was launched
– A total of RMB 230 billion has been spent on returning farmland to forests
– More than RMB 20 billion has been spent on the prevention and control of desertification
– About RMB 500 million is spent on shelterbelt projects every year
– RMB 465 million is spent on forest management, prevention and control of pesticides each year
– More than RMB 300 million is spend on seedling cultivation, state-owned forests and forest parks every year
– Nearly RMB two billion has been spent on wildlife and natural reserve protection. Twenty-six new natural preserves have been established. The total area of these new reserves is 1.845 billion *mu*, accounting for 12.85 % of the national territorial area.

The deepened reform in the forestry sector and increasing funds invested have infused a new vitality to afforestation and landscaping. In the past, the investment in afforestation was only a few yuan per *mu*. But now, the investment has been gradually increased to RMB 50 → and 100→, and now 200 per mu. This has not only motivated tree planters, but also significantly improved the quality of afforestation. Particularly, the adoption of some supportive afforestation and landscaping policies and the reform on the management systems have accelerated the pace of afforestation and landscaping. The revocation of tax on native agricultural and forestry products has provided foresters further incentives for cultivating seedlings and growing cash fruit trees, and advanced the progress of landscaping.

7.2.4 The Area of Afforestation and Landscaping Is Expanded

In the wake of ecological crises including climate change, land desertification, wetland shrinkage, water scarcity and soil erosion, drought and species extinction, forestry is drawing growing concern from all sectors. Making use of forests for its sequestration capacity has become a primary approach to addressing climate change. After 7 years of concerted effort from all signatory countries, the *Kyoto*

Protocol finally became effective on February 16, 2005. Many countries are taking their own measures. The State Forestry Administration of China established a steering committee on climate change and a carbon sink management task force. It launched the first China Green Carbon Foundation projects in seven provinces and autonomous regions. In December 2007, at the 13th session of the Conference of the Parties to the UNFCCC (United Nations Framework Convention on Climate Change), the forest emission reduction was listed as an important part of the Bali Road Map. It is expected that part of the 20–40 % of the emission reduction target will be fulfilled through afforestation, tending enhancement, deforestation reduction and forest degradation control. Moreover, forest biomass energy has become a strategic option for countries around the world to alleviate energy crisis. By equivalent, forest biomass energy is the fourth largest energy, following coal, oil and natural gas. Some experts have measured that, by the middle of this century, biomass fuel will cover more than 40 % of the world's total energy consumption. Attaching great importance to biomass energy, China has started to plant bio-energy trees in large quantities, develop biomass energy and build biomass power plants.

7.2.5 A New Vitality Has Been Infused into Forest Management

Forest management provides an important means to improve forest quality. The requirement of employing 30 % of the effort in afforestation and 70 % in forest management had been merely a slogan. For many years, forest management had remained a weak link in afforestation and landscaping. As reform deepened, people's awareness enhanced, technology advanced and investment increased, forest management is now on top of the agenda. At the national director-general of administration meeting in 2008, Jia Zhibang, Director of State Forestry Administration, mentioned several times in his report that forest management should be intensified. Each year, about RMB 50 million is spent on forest management. The tending of 1.56 billion *mu* of non-commercial forest is enhanced and a plan is made for it. The annual investment in the cultivation of rare tree species amounts to RMB 20 million. Region-specific long-term strategies are made according to local conditions for 208 species of trees. This is an important move. The prevention and control of forest diseases and pests are enhanced and the annual investment is up to RMB 400 million. A number of measures have been taken for the forecasting, prevention and control of forest diseases and pests for key species in key areas. The prevention and control of major pests is strengthened. Consequently, fall webworms are effectively controlled to prevent any swarm.

7.3 Three Weak Links

7.3.1 Forest Management Is Still a Weak Link in Afforestation and Landscaping

In recent years, the leadership has paid much attention to forest management. However, specific work still needs to be strengthened. First, investment is limited. Currently, there are a lot of middle-aged and young forests that need to be tended. The investment of RMB 40–50 million is insufficient. Second, forest management law needs to be constituted to define the management subjects, responsibilities, management procedures and interests. Third, plans, management programs, and implementation methods should be worked out. Fourth, supporting policies should be provided to straighten up internal relations.

7.3.2 Seedling Cultivation Is the Foundation of Afforestation

According to years of experience, fine breeds and strong seedlings are crucial to the success of afforestation and landscaping. Currently, 30 billion seedlings are grown each year, about one a third of which come from state-owned seedling nurseries and 43 % of which are of fine breeds. However, the practice of cultivating seedlings and planting trees indiscriminately is not completely reversed yet. This is also a contributor to the poor forest quality in China. Several years ago, a number of state-owned seedling nurseries were established and the investment was increased. Nevertheless, the annual investment is about RMB 100 million. This is quite disproportionate to the annual investment of more than RMB 10 billion in afforestation. Seedling cultivation techniques have been significantly improved in recent years, with a series of laws and regulations promulgated, including the *Administrative Measures for Forest Genetic Resources*. However, technological research has yet to be further enhanced.

7.3.3 Afforestation and Management in State-Owned Forest Zones Should Be Further Enhanced as Special Cases

Afforestation and management in state-owned forest zones is quite different from afforestation by collectives and individuals. As a result of institutional reform, state-owned forest zones have undergone great changes in terms of management system, investment and management approaches. However, some measures are still not effective enough, and specific researches should be made into this respect Moreover, the reform should be further deepened to enhance afforestation and management.

This year marks the 30th anniversary of the reform and opening up in China. In review of the development course of various undertakings, we can see that they are all boosted by the strong impetus of reform and opening up. Practice has proven that the progress of afforestation and landscaping in China has also been empowered by reform and opening up. In the face of new tasks in the new period and the great demand from all sectors of society, the forestry sector is endowed with even greater responsibilities.

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Chapter 8
Build a Green Grass Industry to Address Four Major Problems

Li Yutang

8.1 The Sustainable Development of National Economy and the Improvement of People's Livelihood Call for a Green Grass Industry

Currently, China's total grass acreage amounts to six billion *mu*, which ranks the second in the world and comes in various types (17 categories and over 1000 types). The country also abounds in forage resources (more than 7000 natural forage cultivars, 385 of which have been approved for cultivation), outnumbering any other country in the world. This presents exceptionally good conditions for the growth of the grass industry in China. At the beginning of reform and opening-up, some central leaders, including Deng Xiaoping and Hu Yaobang, gave a series of scientific instructions and guidelines on developing the grass industry, strengthening grassland management, formulating grassland laws, advancing animal husbandry in pasturing areas, growing grass to control soil erosion, implementing forage aerial seeding, developing pasturage to flourish animal husbandry, transform landscape and help the poor become rich, and growing grass and bushes in areas not suitable for afforestation. Based on policies outlined by the central government and his own field survey, Academician with China Engineering Academy Qian Xuesen proposed a theory on developing a knowledge-intensive grass industry. In practice, China has established a fundamental engineering theory and model, thus laying the ideological and theoretical foundation for the development of the grass industry across the country.

However, blocked by traditional visions, the management of grassland and development of the grass industry has yet to be listed as a strategic priority on China's economic development and land administration agenda. As the nation's

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grassland management mechanism still quite weak, more than 500 million *mu* of grassland has been destroyed by reclamation in the past five decades. Meanwhile, the number of livestock in pasturing areas has increased over 4.5 times. Moreover, due to poor grassland construction and limited investment (the input of central government on grassland stood at RMB 0.02 per *mu* between 1978 and 1999, and has been RMB0.27 since 2000), over 90 % of the grassland has degraded into source areas for water erosion, land desertification, stony desertification and sand storms. In term of the ecological management of land, ignorance of grassland as the management subject and the optimization functions of grass and bushes, as well as the blindness in adopting the policy that equals afforestation to tree planting have given rise to the "local improvement but overall deterioration" situation that is hardly reversed however money and time is consumed. In the development of agriculture, rural areas and farmers, China focuses its attention on the preservation of 1.8 billion *mu* of farmland, but ignores growing grass for soil fertilization and drying quality forage to substitute feed grain. As a result, soil in farmland hardens and degrades, non-point source pollution by fertilizations deteriorates, the scramble for food between people and livestock intensifies, and the food prospects tighten. In the development of biomass energy, the rich biological space of grassland is ignored while the space for crop land and woodland is quite limited, so many difficulties lie ahead. In the process of developing animal husbandry in poor and remote mountainous areas, the advantages of local grassland and mountains and forage resources are neglected, so the grass industry has not grown into a pillar industry that eventually leads to the overall regional economic development. Consequently, local people have remained poor and land sterile for a long time. This in turn widens the development disparities between different regions across China.

This shows that the existence of, and resolution to, problems arising from China's national conditions is closely related to the scientific utilization of grassland that almost makes up half the area of the country and the development of a green grass industry. To ensure sustained and sound development of national economy and people's livelihood, we should list the development of the grass industry and the implementation of the "building a strong grass industry" strategy on top of the agenda of CPC and the state.

8.2 Theoretical Connotations and Scientific Characteristics of Knowledge-Intensive Grass Industry

In 1984, Academician with China Engineering Academy Qian Xuesen first proposed to establish a knowledge-intensive grass industry to embrace the 6th industrial revolution. The basic implication is to synthesize forage with solar power and then use forage to raise livestock and establish a highly comprehensive industry system that creates material wealth by biological, chemical, mechanical and other

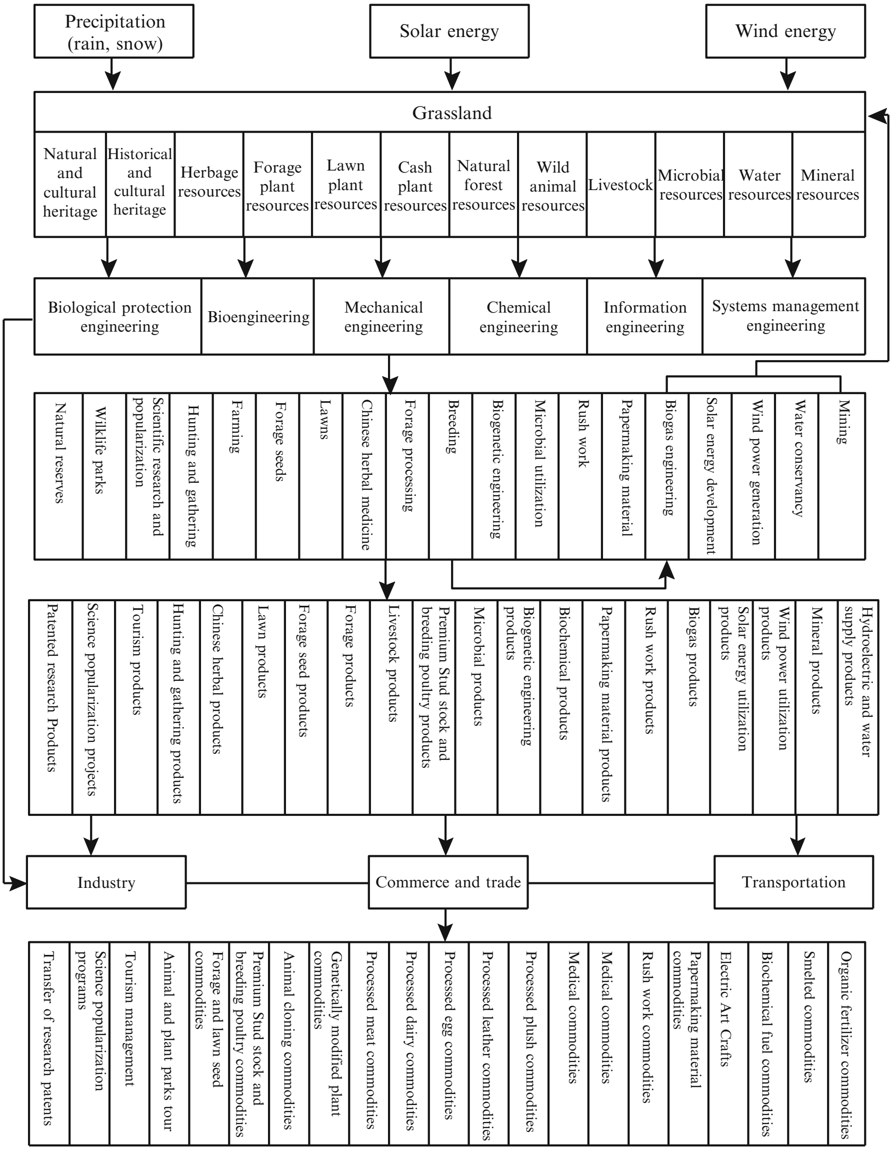

Fig. 8.1 Sketch of a knowledge-intensive grass industry

available modern technological means. In addition to integrated forage and livestock management, there are also many other operating activities that are involved, including plantation, forest management, feedstuff, processing, mining, hunting, tourism and transportation. The grass industry also represents a huge, complicated production and operation system that needs to be managed with a systems engineering theory (See Fig. 8.1).

This shows that the knowledge-intensive grass industry has the following three key scientific characteristics:

1. It applies the scientific principle of material formation and transformation to the development of grassland resources and the management of grass industry. As the major resources of grassland are green grass and shrubs which serve as the foundation for animal breeding, the secondary and tertiary industries, in the process of grass industry development, top priority must be placed on the protection of ecology and the development of grassland planting. Otherwise, the industry will decay due to the loss of foundation. Therefore, green is the first scientific characteristics of the grass industry.
2. The scientific principle of comprehensive resource utilization and energy cycling runs through the whole grass industry system. As a result, the previous simple operation mode that segmented growing, breeding, processing and selling is transformed into a big, multilayer industry economy that integrates growing, breeding, processing and trading. The products and by-products of each layer are the production materials of the next layer until they become commercially available commodities. As a result, wastes from all production processes can be recycled to conserve resources, increase benefits, prevent and control pollution. Consequently, resource conservation and recycling is the second scientific characteristic of the grass industry.
3. It organically combines production with scientific management. This way, malpractices that often occur in the development of enterprises, including emphasizing production and ignoring management, laying stress on economy while downplaying ecology, and pursuing profit while ignoring pollution treatment, can be effectively prevented to make sure that the grass industry can follow the green road that complies with the scientific outlook on development.

8.3 Composition and Comprehensive Utilities of Grass Industry System

According to the theories of the systems science on grasping the principles of matters, affairs and humans, in line with the production and management scope involved in the grass industry, and in reference to the historical experience of animal husbandry in grassland, we established a basic grass industry system in pilot practice. That is, we divided the grass industry into two systems: a production system and a business management system (both containing a scientific research and education system), nine subsystems and their operating systems. Through system coupling and optimization, the grass industry will eventually achieve the capital accumulation, turnover and expanded reproduction described in Karl Marx's *Das Kapital* (See Fig. 8.2).

This shows that the comprehensive utilities of the grass industry system are:

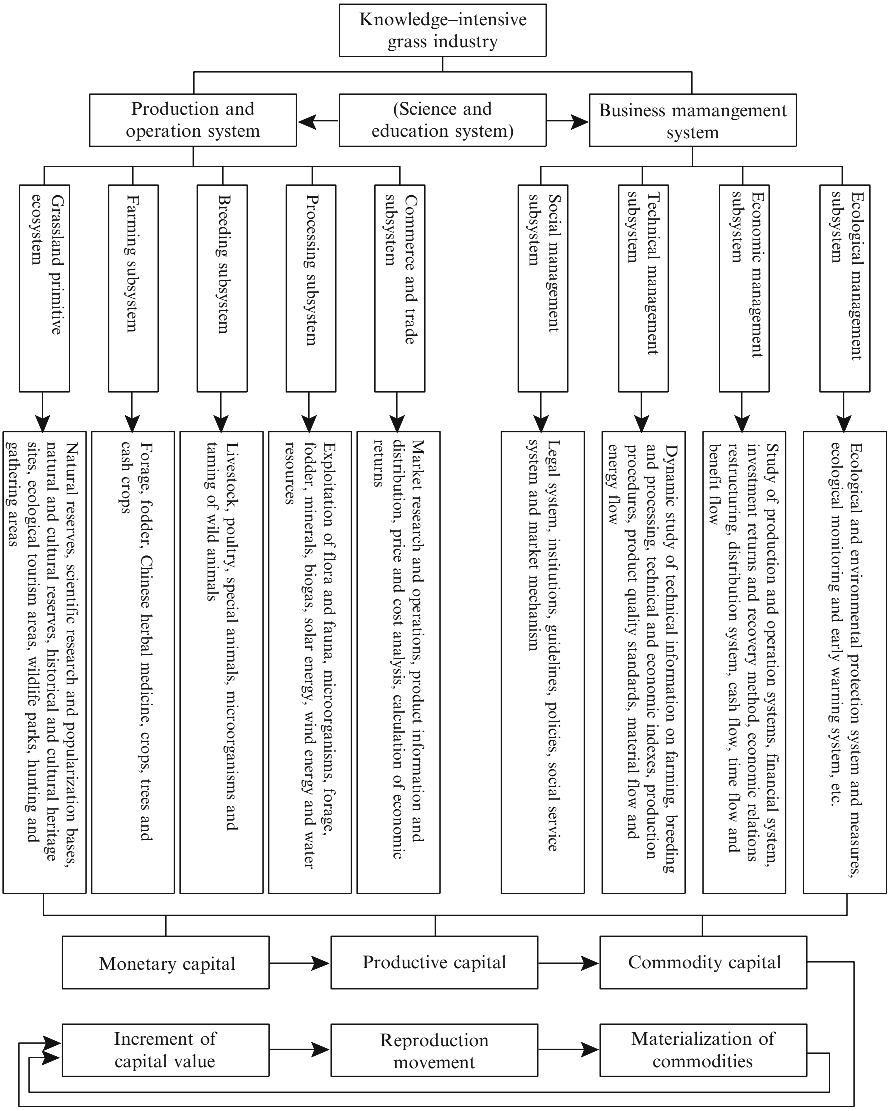

Fig. 8.2 Composition of a grass industry system

1. It combines macroscopic planning with microscopic implementation, straightens up the schema levels of the industry and optimizes the systems in an ascending manner so that projects are deployed from macro scale to micro scale and implemented the other way round to ensure project success;
2. It combines production technologies with scientific management. This enables enterprises to both increase productivity and coordinate internal and external productions so that they will coexist and complement each other. Particularly, in

the management system, ecological management is listed among the nine major subsystems. This can ensure the green nature of the grass industry;

3. It serves as the overall blueprint and mirror for the operation of grass industry projects. This allows enterprises to keep hold of the overall conditions of the project, arrange for and check the implementation progress and quality so that any problem is immediately identified and addressed, and the desired goals achieved.

8.4 Practice Patterns and Optimization Functions of Grass Industry System

In the 1980s, China created its own basic pattern for systems engineering of its grass industry after more than 10 years of practice in over 40 pilot projects across 20-plus provinces (see Fig. 8.3).

The pattern is to define an overall goal (the development of a specialized, socialized and commercialized modern grass industry cooperative economy), adopt three three-in-one policies (combination of growing, breeding and processing, combination of production, research and training, as well as combination of animal husbandry, industry and commerce), and take five reform measures (reform of the management system, production technologies, economic management, distribution system and management methods).

Following this aforementioned pattern, the pilot projects created specific patterns with their own characteristics, including the family ranches at Wugudi Village of Dalad Banner, an arid grassland in Western Inner Mongolia, the irrigated grassland animal husbandry associations in Fukang, a desert steppe area in Xinjiang, the modern grass industry technology cooperative ranches at Zhuopu of Weining, an alpine area in Guizhou, the grass growing and livestock breeding associations in Qujin, a red soil and barren mountainous area in Yunnan, the integrated forage growing, cow breeding and milk processing at Nanshan Ranch of Chengbu, a mountainous area in Hunan, the forage growing, livestock breeding and milk processing in the barren mountainous areas of western Hubei, the integrated grassland animal husbandry development at Baisha, a tropical mountainous area in Hainan, the integrated fruit and grass growing in sub-tropical hilly mountainous areas of Guangdong, and the integrated fishing and grass growing in saline-alkaline low land of Ninghe, Tianjin. Optimized management systems and technologies, high economic, ecological and social benefits commonly characterize these patterns. Some projects are close to or even equal to the production capacity of their counterparts in developed countries.

The optimization functions of these patterns include the following:

1. They address the long-standing challenges in the development of grassland animal husbandry by grasping the key points, taking systematic countermeasures and putting theories into practice. This makes them easily operable;

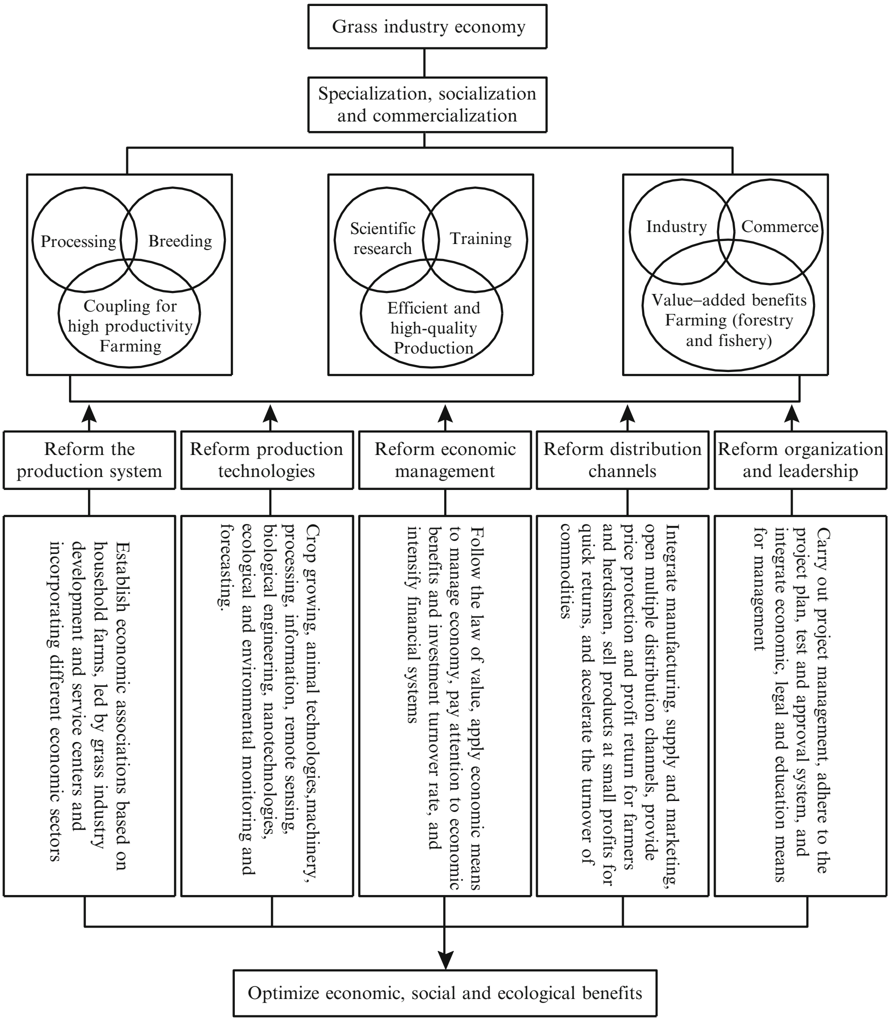

Fig. 8.3 Basic model of grass industry system

2. The pattern framework can incorporate different scientific implications and construction scales. This way, it will be able to gradually increase the technological content and upgrade it from a lower grade to a higher one. Therefore, it is highly feasible and adaptive to regions with different conditions;
3. They reform the current production, management and circulation regime of existing farming and pasturing areas, and asset up grass growing-animal husbandry-trade integrated economic unions based in specialized family farms/ranches and led by animal husbandry, industrial and commercial enterprises as the carriers. This provides an effective approach to transform the dispersed small

farming (animal husbandry) economy in farming and pasturing areas into a large-scale cooperative economy.

8.5 Implementing the Strategy of Building a Powerful Grass Industry to Address Four Difficult Problems

In with the light of the main difficulties in ecological, economic and social sustainability, China should rapidly adopt the strategy of building a powerful grass industry, and define the development of a green grass industry as a national policy and a task of top priority. To this end, we should pool human, financial and material resources, develop dedicated plans, policies and measures and set up a specialized agency under the State Council to govern grassland and the grass industry so as to ensure the achievement of strategic objectives.

8.5.1 Solve the Problem of Shrinking Farmland and Food Shortage

Should we plan to, within the next 5–10 years, grow one billion *mu* of fine forage, this would produce more than one billion tons of high-quality forage (dry basis) per year. If 30–50 % of the forage were used to substitute feed grain (the remaining forage would be used to feed grass-eating poultry), 300–400 million *mu* of farm land can be used to grow more than 100 million tons of grain instead of feed every year. The added grain could significantly guarantee China's lasting food security and some of it could be exported to food-deficit countries.

8.5.2 Solve the Problem of Developing Biomass Energy

Should we plan to, within the next 10–15 years, grow one billion *mu* of grass and shrubs in grassland, mountains, slack farmland, forest gaps and marginal land, this would produce three billion tons of biomass fuels every year, equivalent to 1.5 billion tons of standard coal. Plus the usable wastes from farming and forestry, China's bio-fuel output would exceed that of the U.S. to meet domestic demand.

8.5.3 Solve the Problem of Ecological Land Management

Should we plan to, within the next 5–10 years, restore vegetation in degraded grasslands and mountains through grass improvement without neglecting afforestation, the amount of carbon sink would reach 131.4 billion tons per year or 2.4 times the world's current total emissions of carbon in greenhouse gases. Grass could be grown in urban and rural areas to cover all bare land. Moreover, afforestation, grass growing and livestock breeding (barn feeding) could be integrated in forest areas to bring ecological and economic benefits. This would surely bring China to the world's top in term of ecological land management and contribution to global carbon sink.

8.5.4 Solve the Problem of Ecological Economic Development in Old Revolutionary Bases, Ethnic Minority Regions, Border Areas, Pasturing Areas and Mountainous Areas

Should we plan to, within the next 10–15 years, develop integrated economic entities engaged in grass growing, livestock breeding, processing and trading in old revolutionary bases, ethnic minority regions, border areas, pasturing areas and mountainous areas, enterprises could bring along farmers and herdsmen, and small farming and pastoral economic organizations could be organized into large-scale economic cooperatives. Moreover, we could develop the production and management systems of the grass industry to drive all other sectors and small towns so that farmers and herdsmen could become rich, enterprises could develop and these areas can prosper.

As academician Qian Xuesen once remarked, the development of the grass industry is an important century mission and an issue concerning future generations. We should vigorously publicize the bright prospects of a knowledge-intensive grass industry and the 6th industrial revolution. We should also look out to the twenty-first century and see the bright future. Once a beautiful future is in view, the Chinese people would create this future through revolutionary practice," he noted.

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Chapter 9
Brief Review of Low-Carbon Agricultural Economy

Wang Yun

Climate changes caused by increased carbon dioxide (CO_2) concentration in the atmosphere pose a daunting challenge to human survival and development. Consequently, the international community has recently come up with a countermeasure, i.e. to develop low-carbon economy, with the emphasis on efficient energy utilization and a clean energy structure in the industry. The low-carbon agricultural economy should be an integral part of low-carbon economy that can also do something about global climate change. This role, however, has never been discussed yet. In this paper, we will try to give a brief review.

9.1 The Low-Carbon Agricultural Economy Is a "Three Low" Economy

The term low-carbon economy is defined as an economy that emits the lowest greenhouse gases but yields the highest social output. Many people would disapprove of the idea of relating agriculture to low-carbon economy which emphasizes on the reduction of greenhouse gas emissions. In their eyes, agricultural products resulting from plantation and breeding are least associated with greenhouse gas emission. This view may sound reasonable, but an in-depth analysis would reveal that it does not accord with the reality of agricultural production and management.

First, in terms of agricultural inputs, they include products from both agricultural activities, such as seeds and organic fertilizers, and industrial production, such as chemical fertilizers, pesticides and agricultural films. The former do not have much

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correlation with greenhouse gas emission, but the latter are highly correlated with greenhouse gas emission.

Second, in terms of agricultural machines, they can't be manufactured or used without electricity, oil and other energy. During the planting, harvesting and field management period this summer, diesel oil was in short supply across China. In this context, the central leadership made important instructions that the material supply for agricultural production should be guaranteed to meet the need of agricultural production. This is a powerful example.

Third, in terms of the processing and distribution of agricultural products, the use of energy is indispensable. When they are sold, agricultural products, whether packed or not, would consume some materials, such as packing bags used in farmers markets and supermarkets.

Last but not least, in terms of the treatment and recycling of wastes from agricultural activities, they would also consume energy. The treatment without using power is only a low-level treatment.

In summary, we can conclude that agriculture is correlated with energy consumption and greenhouse gas emissions before, during and after agricultural production. The correlation is quite close in some aspects. From the concept of low-carbon economy, it can be deduced that the low-carbon agricultural economy should be an economy that emits the lowest greenhouse gases in agricultural production and management but yields the highest social output.

The low-carbon agricultural economy is a "Three Low" economy, i.e. low energy consumption, low pollution and low emissions. It is an conservation-oriented economy which reduces the consumption of various resources as much as possible and minimizes the input of human, material and financial resources. It is also a benefit-minded economy which yields maximum social output with minimum material input. Moreover, it is a safety-oriented economy which tries every means to minimize possible negative impact of agriculture before, during and after production on society.

The development of low-carbon agricultural economy is urgently required needed to cope with global climate change and reduce greenhouse gas emission. Currently, global climate change has become an important issue to the common concern of all mankind. In February of 2007, the Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC) noted that, according to direct instrument observation, the annual mean ground surface temperature around the world rose had risen by 0.74 Celsius degree around the world in over the 100 years from 1906 to 2005, and the linear temperature increase has risen by 0.13 Celsius degree per decade over the most recent 50 years. Greenhouse gases such as CO_2 from burning fossil fuels have directly led to the carbon cycle changes in the Earth system, which has in turn caused increased greenhouse gas concentration in the atmosphere. Observations have indicated that the CO_2 concentration in the atmosphere around the world rose from about 280 ppm before industrialization to 379 ppm in 2005. Currently, the CO_2 concentration in the atmosphere has gone far beyond the natural variation limit over 650,000 years. Severe consequences from global climate change, including sea level rising and frequent occurrence of extremely disastrous climates, is already jeopardizing food security, water resource utilization and coastal cities, posing a severe threat to human and social sustainability. In this context, the United Nations and industrialized countries have taken positive actions to cope with global climate change. In June 1992, at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro of Brazil, more than 150 countries jointly drafted the *United Nations Framework Convention on Climate Change* (UNFCCC). This marked the first convention to address the negative impacts of global warming on economy and society by controlling the emissions of CO_2 and other greenhouse gases. In December 1997, in Tokyo Japan, representatives from 149 countries and regions voted through the *Kyoto Protocol* that aims to cap global warming by limiting greenhouse gas emission by developed countries. On the World Environment Day of 2008, the United Nations Environment Program set the theme to be "Kick the habit! Towards a low carbon economy". In July 2008, the G8 Summit held in Tokyo defined a target to cut global greenhouse gas emission by at least a half by 2050.

For many years, China has attached great importance to coping with climate change and developing low-carbon economy. On May 30, 2007, China's fundamental law on climate change, *China's National Climate Change Program* (CNCCP), was adopted by the executive meeting of the State Council. In the report delivered by then General Secretary Hu Jintao at the 17th CPC National Congress, it was explicitly stipulated that we should strengthen the conservation of energy and resources, intensify environmental protection and enhance sustainability; implement an accountability system for energy conservation and emissions reduction; build up the capacity to cope with climate change and make new contributions to the protection of global climate. Since last year, China has implemented some energy conservation and emissions reduction policies, which substantially facilitates the development of low-carbon economy. It is true that the industrial sector should take up its responsibility, but the sectors concerning agriculture, farmers and rural areas should also shoulder their responsibilities for developing a low-carbon economy. Developing a low-carbon agricultural economy has become a top priority.

Developing low-carbon agricultural economy is an urgent task for agricultural restructuring and modernization. On the one hand, global climate change has brought severe threats to social and economic sustainability. Some experts analyze that climate change in the future will see its most severe impact on farming, animal husbandry, ecosystem, water resources and coastal areas. Climate change will add to the volatility of agricultural production and yield. This signifies new requirements for agricultural restructuring. There is no turning back in developing low-carbon agricultural economy that fits well in climate change and reduces greenhouse gas emission. In the process of building a new socialist countryside, local governments have beefed up their work on agricultural modernization. A modern agriculture requires the modernization of agricultural facilities and the application of advanced equipment in agriculture. This calls for vigorous advancement of agricultural mechanization. Clearly, only agricultural machinery featuring low energy consumption, low pollution, low emissions and high benefit has the vitality. To develop a modern agriculture, we need to modernize agricultural technologies, promote the use of advanced, energy-efficient, resource-conserving and environmentally-friendly agricultural technologies, innovate in energy utilization technologies, improve energy utilization efficiency and increase the proportion of clean energy. A modern agriculture also calls for managerial modernization. Only when the brains of management staff are armed with the concepts of high-efficiency agriculture, clean agriculture and safe agriculture and their work is guided with relevant institutions can twice the result be achieved with half the work. This shows that the model of agricultural economy featuring low energy consumption, pollution and emissions accommodates agricultural modernization and emerges in response to global climate change.

Developing low-carbon agricultural economy is urgently required to improve rural environment and farmers' living quality. In the process of building a new countryside, local governments have earnestly tried to improve rural environment. As a result, many places take on a new look. However, the improvement of rural environment is a long-term task. There are still some problems in many regions, including the nerve-racking agricultural diffused pollution caused by overuse of pesticides, chemical fertilizers and agricultural film, the pollution caused by agricultural product processing plants, the high energy consumption and emissions of exhausted gases by some agricultural machines, the air pollution caused by the burning of straws, and the disposal of waste from animal husbandry, such as livestock and poultry manures. These long-standing problems not only affect the environment, but also lower farmers' living quality. To effectively address these problems, both temporary and permanent measures should be taken. The temporary measure is to improve agricultural ecological environment and rural environment, and solve the problems one by one and region by region. The permanent measure is to develop a low-carbon agricultural economy, and replace the pattern of agricultural economy characterized by high energy consumption, high pollution, high emissions and low benefit with one featuring low energy consumption, low pollution, low emissions and high benefit so as to benefit farmers with good profits and a sound environment for comfortable living, relaxation and happiness.

9.2 Patterns of Low-Carbon Agricultural Economy Already Exist in Vast Rural Areas

Low-carbon economy is a term that emerged only in recent years. The term low-carbon agricultural economy is never heard of before for most people. But a careful observation will reveal that, thanks to our many years' alertness on the ecological environment of agriculture and recent concern about a circular agricultural economy, low-carbon agricultural economy is already seen in the vast rural area. The diverse forms of low-carbon agricultural economy can be roughly categorized into the following patterns:

9.2.1 Reduction and Substitution of Harmful Inputs

The use of chemical fertilizers, pesticides and agricultural films is the application of industrial revolution outputs in agriculture, which can significantly increase agricultural output. However, its negative aspects shouldn't be overlooked, including toxic residues in agricultural products, agricultural diffused pollution and soil degradation. They may not only bring in residual toxin of farm products, but also lead to non-point agricultural pollution and soil degradation that eventually affect the sustainability of agriculture. For many years, great efforts have been employed in different regions to explore the possibility of reducing and substituting chemical fertilizers, pesticides and agricultural films, including the substitution of farmyard manure for chemical fertilizers, the substitution of biological pesticides for chemical pesticides, and the substitution of biodegradable agricultural films for agricultural films not amenable to biodegradation. Formulated fertilization based on soil testing and balanced fertilization by the agricultural sector, i.e. the determination of reasonable fertilization application according to soil conditions and the need of crop growth, is well received by farmers.

9.2.2 Afforestation for Oxygen Generation and Carbon Removal

Afforestation and landscaping helps break wind, fix sand, increase the soil water storage capacity, control water loss and soil erosion, improve the ecological environment and mitigate natural disasters. Developing cash trees can bring huge economic benefits and promote the sustainability of local economy. Afforestation sink is also a large source of carbon sink. Therefore it is the most cost-effective method to cope with global warming, protect global climate system and ecological environment. The term carbon sink is defined as the process, activity or mechanism in which afforestation, forest management, vegetation restoration and other measures are taken to leverage the photosynthesis of plants to absorb CO_2 in the atmosphere and fix it in vegetation or soil, thereby reducing greenhouse gas concentration in the atmosphere. The photosynthesis of forests can absorb a huge amount CO_2 and release oxygen. According to scientific measurement, a hectare of broad-leafed forest can absorb 1 ton of CO_2 and release 0.73 ton of oxygen that is enough for 1000 people to breathe in every day. Scientific research indicates that trees can absorb 1.83 tons of CO_2 and release 1.62 tons of oxygen for each cubic meter they grow. Every year, forests around the world absorb and store 90 % of the carbon flowing in the atmosphere and on the Earth's surface. Research of some Chinese experts shows that, by planting one hectare of trees, the cost for storing one ton of CO_2 is about RMB 122 in China, in contrast to the hundreds of US dollars needed for non-carbon sink measures. Some experts have estimated that a 200,000 kW coal-fired power plant releases about 0.8778 million tons of CO_2 per year, which can be offset by the CO_2 equivalent absorbed by 32,000 hectares of artificial trees in a year. A round trip of a Boeing 777 traveling between Beijing and Shanghai takes about 4 h. At one round trip per day, it releases about 28,032 tons of CO_2 per year, which can be offset by the CO_2 equivalent absorbed by 1000 hectares of artificial trees in a year. An Audi A4 auto releases about 20.2 tons of CO_2 per year, which can be offset by the CO_2 equivalent absorbed by 0.7 hectare of artificial trees in a year.

9.2.3 Farmland Conservation Through Stereoscopic Plantation and Breeding

Stereoscopic lantation and breeding fully leverages land, sunshine, air and water, extends the space for things to grow, increases the yield of agricultural products and improves the benefit. In the Jianghai Alluvial Plain of Jiangsu Province, the common practices of stereoscopic plantation and breeding include growing vegetables in mulberry field in autumn and winter, intercropping corn in mulberry field, intercropping wheat, soybean and cotton in Italian poplar forest, seedling growing and aquaculture in rice paddies, planting water chestnut and breeding crabs, planting lotus and breeding soft-shelled turtles, and planting lotus and breeding eels, breeding ducks in rice paddies, planting forage under Italian poplar trees, breeding goats, ducks and geese in forests, and the combination of fishery and animal husbandry in water net areas.

9.2.4 Farmland Expansion Through Reclamation

In China, the per capita arable land area is only 1.38 *mu*, which is less than 40 % of the world average. Maximizing the arable land area and minimizing land use is an important foundation for agricultural sustainability. In riverside and coastal areas, farmland is increased mainly through reclamation. Since the founding of the People's Republic of China in 1949, more than 1.3 million *mu* of farmland has been reclaimed from tidal flats in Nantong, Jiangsu Province, a riverside and coastal area. A number of farming, forestry, animal husbandry and aquaculture bases have been established in the reclaimed land. Land reclamation refers to the process in which remedial measures are taken to restore land damaged by digging, land subdue, production and construction back to usable state. Most wastelands can be restored into farmland through remediation, and some wastelands can serve other agricultural and industrial purposes after remediation.

9.2.5 Water Conservation

At present, about 400 billion cubic meters of water is consumed by agriculture in China every year. This accounts for 68 % of the country's total water consumption, making agriculture the largest water consumer in China. Particularly irrigation alone consumes 360–380 billion cubic meters or more than 90 % of the water used by agriculture. According to calculations of the Department of Rural Water Resources under Ministry of Water Resources, the effective coefficient of irrigative water utilization in China is only 0.46, which means that about half of the irrigative water is not directly used by crops as a result of seepage, evaporation and poor management. After irrigation, the utilization efficiency of farmland water is still quite low. Each cubic meter of water can produce about 1 kg of grain, about half of the level of developed countries. For many years, water-conserving agriculture has been vigorously developed in many parts of China, where scientific engineering measures are taken, and concrete seepage-proof piping and pipeline water delivery processes are adopted to effectively mitigate water seepage and evaporation. Also, outdated mechanical and electrical drainage and irrigation facilities are renovated, water-conserving irrigation for rice paddies, sprinkling irrigation, micro-sprinkling irrigation and drip irrigation technologies are popularized to significantly increase the utilization efficiency of water resources.

9.2.6 Energy Conservation

We should propagate energy conservation technologies to reduce energy consumption by farming, agricultural machinery, breeding and production. Unreasonable farming methods and plantation technologies should be reformed, and energy-efficient farming systems should be explored. Moreover, minimum or even no tillage, direct sowing and other conservation tillage practices should be vigorously promoted. In dry areas, drought-tolerant crops and various dry cultivation technologies should be popularized. In winter, greenhouses that can fully leverage solar power should be built to grow anti-seasonal vegetables. Intensive, efficient and ecologically-friendly livestock and poultry breeding techniques should be propagated to reduce fodder and energy consumption. On top of that, solar power and geothermal resources should be utilized to condition the temperature in livestock and poultry houses to lower energy consumption.

9.2.7 Pollution-Free, Green and Organic Food Bases

Pollution-free, green and organic food is well received by consumers for its good quality, no or little pesticide residue. In recent years, pollution-free, green and organic food production bases have been built in many regions. As a result, the safety of agricultural products is significantly improved.

9.2.8 Clean Energy

The practices of utilizing the abundant resources in rural areas to develop clean energy include wind power generation, straw power generation, straw gasification, biogas and solar power utilization. Particularly, in recent years, a program has been launched in many regions to build biogas digesters, renovate toilets, kitchens and pigsties. It not only helps beautify the environment, but also brings new energy and increases people's income. As a result, it is highly praised by farmers.

9.2.9 Reuse of Wastes from Plantation and Breeding

Wastes from plantation and breeding can be reused in multiple ways to benefit multiple parties. For instance, straws can be returned to the field to raise soil fertility, ammonified to feed livestock, and used to replace wood to produce composite plates, branches trimmed from mulberry trees can be used to grow edible fungus, livestock and poultry manures can be used to produce microbe organic fertilizers, and peanut shells can be crushed into powder for reuse.

9.2.10 Recycling of Wastes from the Processing of Agricultural Products

Many agricultural product processors try every means to recycle wastes from the processing of agricultural products and turn them into wealth. For instance, a rice processor uses premium rice as the raw material to produce refined rice, rice flour and rice starch. The wastes from the processing include rice hulls and rice milk. The processor develops an incineration boiler which burns rice hulls as the fuel. It also extracts starch from rice milk and then extracts glucose and rice protein. The filtered water is delivered to pig farms to feed pigs, and the organic manures from the pig farms are used as a fertilizer at the processor's rice paddies.

9.2.11 Regional Industrial Cycling

An industrial cycling chain can be built between plantation, breeding, processing and circulation in a region to form a virtuous cycle of economic development. Mei'an County of Jiangsu Province, which is famous for initiating the "integrated plantation, breeding and processing and sales" pattern, can be taken as an example. As a well-known production base of silk, poultry and eggs in China, it leverages abundant agricultural and sideline products to raise pigs, sheep, poultry and silkworms. To increase the value of grain, silkworm cocoons, fruits, livestock, poultry and vegetables, a number of agricultural and sideline products processing enterprises were established. They form a comprehensive agricultural and sideline products processing system. This gives rise to a dynamic agricultural and sideline products distribution industry. Poultry, eggs and other products from the county are sent to various places across China. They find their way into supermarkets in large Chinese cities and are even exported to other countries. Thanks to the virtuous cycle of plantation, breeding, processing and sales, the economic competence of Hai'an County is significantly enhanced, bringing the county into the top 100 counties in China.

9.2.12 Agricultural Tourism

In recent years, sightseeing in the countryside has become a stylish leisure option for urban residents. Therefore, agricultural tourism has grown rapidly. Currently, tourism destinations in the countryside include natural scenery spots, historical sites, leisure farms, agricultural high-tech parks, special agricultural product regions, special product markets and famous rural enterprises.

9.3 Vigorously Promote the Sound Development of Low-Carbon Agricultural Economy

The low-carbon agricultural economy is something new that emerges as the international community is working together to cope with global climate change. It is a new economic pattern. We should vigorously promote the sound development of low-carbon agricultural economy in an active manner.

9.3.1 Conduct Vigorous Publicity Campaigns to Build Consensus

As most people still don't know much about low-carbon economy and low-carbon agricultural economy, it is necessary to enhance publicity. We should conduct publicity campaigns at relevant meetings organized by related authorities to enhance the awareness of leaders. All media should be leveraged, including newspaper, radio, TV and Internet to publicize low-carbon economy and low-carbon agricultural economy whenever and wherever possible. Blackboards and bulletin boards in residential districts, businesses and other public places should be used. Also, various materials should be printed and distributed, and loudspeaker vans dispatched to neighborhoods. In this way, low-carbon economy and low-carbon agricultural economy can become a household concept. The importance and urgency to cope with global climate change, and to develop low-carbon economy and low-carbon agricultural economy can be deeply rooted into people's minds. Moreover, the patterns of low-carbon agricultural economy can become well known to the public, and the measures to promote low-carbon economy and low-carbon agricultural economy well understood so that people can act voluntarily.

9.3.2 Make Plans and Define Targets

So far, plans for a recycling agricultural economy have been worked out in many regions. On the basis of these plans, we can make a plan for low-carbon agricultural economy. To make the plan, we should take the scientific outlook on development as the guidance, start with the impact of global climate change on local environment, take local conditions into consideration and define development targets and measures that are viable for a certain period. The plan should include medium and long-term targets for the year 2020 (the year to fulfill the target of building China into a relatively well-off society), the periodical target for the end of the 11th Five-Year Plan period (2010) and the end of the 12th Five-Year-Plan period (2015), and annual targets for the coming 3–5 years. It should include economic development targets, and restrictive targets for energy conservation and emissions reduction. The plan should highlight the development of low-carbon and high-efficiency agriculture and take it as the guide. In addition, it should specify key programs and measures for the development of low-carbon agricultural economy at different phrases, and particularly it should specify supporting measures. On top of that, it should calculate the total input demand and compositions for the development of low-carbon agricultural economy at different phrases and identify the input channels to meet the development needs.

9.3.3 Choose and Implement Appropriate Patterns

There are many patterns for the development of low-carbon agricultural economy. So different regions should choose and implement appropriate patterns that fit in with local conditions. Actually, there are many patterns of low-carbon agricultural economy created by farmers in different regions. These patterns are suitable for local conditions, and are very vital. So we should first sum up these patterns and choose those that are cost-effective and adaptive to most local villages and farmers and summarize them into economic models for popularization. We should also choose development patterns of low-carbon agricultural economy from other regions, and combine such patterns with local conditions for popularization. Moreover, we should draw an easy-to-understand chart for popularizing the patterns of low-carbon agricultural economy so that farmers can follow it without any difficulty. On top of that, we should summarize the achievements in popularizing the patterns of low-carbon agricultural economy in a timely manner, and award the pioneers that make remarkable achievements to guide and spur more people to follow.

9.3.4 Highlight Key Points and Prioritize Technologies

A lot of work needs to be done to develop low-carbon agricultural economy. But if we go about several tasks at a time without clear distinction between primary and secondary tasks, it's impossible to obtain a desirable result. So we should highlight and focus on key points for the development of low-carbon agricultural economy. As such, we should concentrate on two tasks. On the one hand, we should vigorously scale up the low-carbon high-efficiency agriculture so that farmers can benefit from the development of low-carbon agricultural economy. To this end, we should lay special stress on the development of pollution-free, green and organic food, focus on the production bases of such food and improve their quality. Also, we should still pay attention to the construction of agricultural infrastructure, further improve agricultural production conditions, advance afforestation and improve agricultural ecological environment. On the other hand, we should make great effort to advance energy conservation and emissions reduction in agriculture to make real contribution to coping global climate change and reducing greenhouse gas emission. To this end, we should actively promote green energy in rural areas, develop wind power, solar power and stalk gasification in line with local conditions, household biogas and biogas projects in medium- and large-sized livestock and poultry farms in rural areas, phase out and update obsolete energy-intensive agricultural machines and fishing boat equipment. We should also accelerate the updating and renovation of electromechanical water irrigation and drainage facilities for agriculture, minimize the use of hazardous materials, recycle and properly dispose of farming wastes and wastes from agricultural product processing. Both tasks require the propagation of new technologies. In the process of advancing low-carbon agricultural economy, we should focus on the propagation of low-carbon and high-efficiency farming, comprehensive resource utilization, sound livestock and poultry breeding, agricultural ecological protection, standardized low-carbon agricultural product production and processing, energy conservation, emissions reduction, water conservation, green energy and comprehensive waste utilization technologies, and constantly improve these technologies in practice.

9.3.5 Intensify Leadership and Interaction

CPC committees and governments at all levels need to intensify their leadership in low-carbon agricultural economy, list it high on their agenda, resolve important issues for the development of low-carbon agricultural economy in a timely manner by preparing plans, specifying support policies and adopting key measures to promote the sound development of low-carbon agricultural economy. The leaders specifically assigned should steadily attend to the whole work. Moreover, major leaders should attend to some important links. The development of low-carbon agricultural economy involves many departments. So the responsibilities of these departments should be clearly defined and their fulfillment should be inspected on a regular basis. These departments should not only fulfill their own responsibilities for the development of low-carbon agricultural economy, but also enhance inter-departmental collaboration and work in unison for synergy. A well-established and complete statistical, monitoring and evaluation system for the development of low-carbon agricultural economy should be put in place to always stay updated on relevant data, and such data will be analyzed to specify the future development direction. We should independently formulate laws and regulations governing low-carbon agricultural economy or add relevant contents to laws and regulations concerning recycling economy and recycling agriculture. In either case, there should be laws to abide by for the development of low-carbon agricultural economy and such laws should be strictly observed. A complete investment mechanism should be established for low-carbon agricultural economy. The fiscal investment should play a leading role, while industrial, commercial, private and foreign investment should be encouraged so as to shape a good situation where the whole society is engaged in the development of low-carbon agricultural economy. Farmers should be encouraged and well supported to establish economic cooperatives relating to low-carbon agricultural economy. Leading agricultural product processing and distribution enterprises in connection with low-carbon agricultural economy should be actively supported. Moreover, a system should be established for the propagation of low-carbon agricultural production technologies to provide necessary technical guidance for farmers in a timely manner. In addition, demonstration enterprises and farmers should be cultivated for low-carbon agricultural economy to give full play to their role of passing on experience and helping.

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Chapter 10
Innovation and Development of Ecological Economy in the Poyang Lake Basin

Wu Guochen, Ouyang Ming, and Wu Yue

In the spring of 2008, Jiangxi kicked off a pilot program for ecological economy in the Poyang Lake Basin with the support of various ministries and commissions under the central government. The establishment of Poyang Lake Pilot Ecological Economic Zone is a major strategic move to implement the scientific outlook on development in line with the actual conditions in Jiangxi Province and the country as a whole, a scientific decision concerning the long-term development of the province, and also an important action to enhance the sustainability of the Yangtze River Basin.

This pilot zone covers the Poyang Lake Basin – the whole Jiangxi Province. In some sense, it renews and further advances the Mountain-River-Lake Program implemented by the science and technology community of Jiangxi Province over the years. But it's not simple inheritance. Instead, it is a significant strategic breakthrough, a shift from the development and management of the hilly or mountainous areas in the middle and upper reaches of the five major rivers in the province to ecological economic development in the Poyang Lake Basin and plains around the lake, and a transition from the management of mountains, lakes, rivers and poverty alleviation to the construction of a new economic system which embraces globalization and an innovation-oriented (resource-conserving, environmentally-friendly and low-carbon-oriented) society. It represents a major innovation and stride leap in the scientific and technological work and the Mountain-Lake-River Program in the great period of strategic opportunities.

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As remarked by U.S. ecological economist Lester R. Brown, economic principles and ecological principles are isomorphic, so economists and ecologists should join hands in building an economic pattern beneficial to the earth – ecological economy.

Ecological economy aims to promote economic and social sustainability on the basis of ecological balance. Technological innovation is the most central issue in building ecological economy. It is not only an effective approach to attain reasonable distribution and conserve resources, but also a dominant force that boosts industrial restructuring and transformation of economic growth patterns, and more importantly, a major means for ecological construction and environmental protection. How to boost the sound and rapid development of ecological economy in the region is the most pressing task for the science and technology community of Jiangxi Province.

10.1 Principles of Technological Innovation in Constructing the Pilot Zone

The science and technology community in Jiangxi, in response to the needs of constructing the pilot zone, should carry out reform and innovation in development concepts, development patterns, sustaining conditions, institutions, mechanisms and self-construction to constantly enhance the vitality and power.

For this reason, when doing scientific and technological work, we must earnestly implement the scientific outlook on development, emancipate our minds, seek truth from facts, adhere to the development strategy outlined in the report to the 17th CPC National Congress to enhance the country's capacity of independent innovation and build an innovative nation. We need to follow the principles of innovating independently, striding across key fields, supporting development and leading the future, set up a concept of broad technology and extensive opening up, push forward concept innovation, independent innovation, institutional innovation and open innovation. In addition, we need to break the major technological bottlenecks of ecological economic development in the Poyang Lake Basin and the institutional and mechanism obstacles that hinder independent innovation. Moreover, we should support and lead the construction of the Poyang Lake Pilot Ecological Economic Zone through technological innovation, achieve the grand goals of rejuvenating Jiangxi in Central China and building a well-off society in an all-round way. We must also pay attention to the following principles in the scientific and technological work for the construction of the pilot zone.

First, adhere to the principle of laying equal stress on protection and development. We should keep a firm grasp on key scientific and technological programs, pursue a resource-conserving, environmentally-friendly and low-carbon-oriented technical pattern, and properly handle the relations between environmental protection and economic development to boost the comprehensive, coordinated and sustainable development in the pilot zone.

Second, uphold the principle of taking all factors into consideration while making breakthroughs in key areas. We should, on the basis of boosting technological development in an all-round way, focus on specific targets and key points, and pool limited technological resources to grasp core technologies in superior domains, secure a commanding position to achieve breakthroughs in and leap-forward development in key areas.

Third, stick to the principle of combining original innovation and integrated innovation with re-innovation after introduction, digestion and absorption. We should, in line with the actual conditions in Jiangxi, advance original and integrated innovation of ecological economic technologies in areas where we have a certain foundation and some advantages to develop some technologies and products with independent intellectual property. We should also uphold the strategy of extensive opening up, and embark on a road of technological development that focuses on re-innovation after introduction, digestion and absorption.

Fourth, insist on the principles of combining market orientation with government guidance. We should follow the market orientation and give full play to the fundamental role of market mechanism in allocating scientific and technological resources. Moreover, we should bring into play the role of governments in leading scientific and technological development and adopt incentive policies to mobilize all social resources to carry out technological innovation for ecological economy.

Fifth, hold onto the principle of combining the development of high-tech industries and the optimization and upgrading of traditional industries. We should vigorously develop high-tech ecological industries, renovate and upgrade traditional industries, promote industrial restructuring and transform the economic growth patterns. We should also gather innovation elements and foster new regional growth poles to enhance the overall technological competitiveness of the pilot zone.

Sixth, adhere to the principle of combining technological innovation with institutional innovation. We should, in addition to vigorously enhancing the capacity of technological innovation, further deepen institutional reform for technological development and innovate in the policy environment to lay a solid institutional foundation for technological advancement in the pilot zone.

10.2 Technological Innovation Strategy for the Construction of the Pilot Zone

The period 2008–2012 was the kickoff stage of ecological economic construction in Poyang Lake Region. The strategic goals of this key period were defined as to study and propagate the resource-conserving, environmentally-friendly and low-carbon-oriented technical pattern for ecological economy, to enhance the research of key technologies, and to strengthen regional independent innovation capacity. We should reform institutions and mechanisms, optimize the environment for innovation and entrepreneurship, build a technological innovation system with regional characteristics and advantages, significantly enhance the capability of technologies to boost socio-economic development and the overall technological competitiveness so as to lead and support the construction of the pilot zone.

First, bring the science theories for integrated basin management represented by the Mountain-Lake-River program and technological innovation to the forefront of the nation, the technological innovation for ecological construction and environmental protection above the average national level and advance the overall technological progress above the average level in China's central regions.

Second, significantly enhance the technological innovation capacity for the ecological industry. To this end, we need to increase investment in technological research in superior domains so as to attain some original research achievements with significant technological value and actively develop high-quality patented technologies and products.

Third, gradually improve the regional innovation system with the characteristics of Poyang Lake ecological economy. We should devote our efforts to the construction of research-oriented universities and technology intermediaries. Moreover, we should encourage relevant medium- and large-sized enterprises to set up ecological technology centers and other R&D facilities.

Fourth, significantly enhance the role of technologies in leading and supporting the construction of the ecological economic zone. By 2012, the contribution rate of technological advancement to economic growth should be over 54 %. A technological support system for social progress and people's livelihood projects that meets the construction requirements of the ecological economic zone should be established to provide powerful technological guarantee for areas like ecological construction, environmental security, disaster prevention and mitigation and emergencies.

Fifth, implement a "talent highland" strategy. We should foster and expand the technological innovation team in ecological economy and enhance the construction of foundation platforms.

10.3 Key Areas of Technological Innovation in the Construction of the Pilot Zone

The core task of technological innovation for Poyang Lake Pilot Ecological Economic Zone is to enhance the capacity of regional independent innovation, promote the coordinated development between regional resources and environment with economy and society and strengthen the region's overall competitiveness.

In the period 2008–2012, the tasks of technological innovation for the pilot zone are mainly concentrated in the following four areas:

10.3.1 Strategic Research

Conception innovation acts as the ideological foundation for theoretical innovation and technological innovation. As part of the innovation development strategy, scientific research is the primary task to accomplish for the leap-forward development of the pilot zone.

We should, apply natural and social sciences in a comprehensive way, study major strategies concerning the development of ecological economy in Poyang Lake Region and pay special attention to top-layer design to back up strategic decision-making for the construction of the pilot zone.

In this area, we should focus on the assessment and prediction of the carrying capacity of the resource environment in the Poyang Lake Basin. We should study the strategy for ecological modernization and leap-forward development of ecological economy in the region. We should also carry out research on low-carbon economy and its development patterns as well as ecology-oriented technological innovation.

10.3.2 Recycling Technologies

Recycling economy is a closed-loop resource recycling economy within the realm of ecological economy. Recycling technologies refer to innovative technologies that follow the rules of material cycle and energy flow in natural ecosystems to form a recycling principle of resources-products-renewable resources so as to maximize socio-economic benefits at the minimum resources and environmental costs. In the development of ecological economy in the Poyang Lake Region, we must vigorously develop recycling technologies, renovate the existing industrial system and build a system of recycling industry, ecological agriculture and modern service industry in the Poyang Lake Basin.

– Give priority to the development of energy conservation, emissions reduction, water conservation and other strategic resource conservation technologies, the development of renewable resources, resource recycling, product symbiosis, ecological design and "Venous Industry" technologies.
– Develop stereoscopic agriculture, recycling and precision agriculture technologies.
– Build a technological support system for modern service industry, increase the technology content and cluster scale of modern service industry, establish three information platforms for business, public and community and community services, create four network clusters of producer services, business services, life services, cultural and tourism services so as to improve the technological level of ecological service industry in the Poyang Lake Basin.

10.3.3 Livelihood Projects

We should comprehensively improve the quality of population and the health conditions of urban and rural residents in Poyang Lake Region, enhance the ability to deal with public safety disasters and public emergencies, protect and improve the ecological environment, break the technological bottlenecks for social development in the region, develop key technologies relating to health, disaster prevention and mitigation, social service and other areas important to people's livelihood, and push green and healthy modern consumption patterns.

10.3.4 Basin Management

We should explore scientific theories, basic strategies and technological approaches for integrated management in the Poyang Lake Basin, create a new basin management pattern that complies with the scientific outlook on development and push the Mountain-Lake-River Program towards a leap-forward development. We should also establish a technological innovation system for environmental protection and resource utilization in line with the pilot zone so as to provide technological support for ecological construction, environmental protection and rational resource utilization.

10.4 Functional Division of the Pilot Zone

According to the geological environment, ecosystem characteristics and the current socio-economic development conditions of the Poyang Lake Basin, the pilot zone can be divided into several functional areas, i.e. the core lake area, the circum-lake plain area and the five-river basin area (i.e. mountainous and hilly areas in the middle and upper reaches of the Ganjiang, Fuhe, Xinjiang, Raohe and Xiushui rivers).

We should, in line with the resource and environmental carrying capacity, define the major functions of different areas and allocate innovation tasks in a scientific manner.

10.4.1 Core Lake Area

The core lake area includes the Poyang Lake water areas and related wetlands. It is specifically designed to enhance ecological functions and restrict economic activities. The innovation task of this area is to conserve the clean water of the lake, study and push comprehensive technologies for natural protection and rational resource utilization, develop wetland industries, increase farmers' income around the lake, expand county-specific economy and propagate knowledge on ecological civilization within the environmental and resource-carrying capacity of this area.

10.4.2 Circum-Lake Plain Area

This area is a key area for clustering industrial technologies and developing ecological economy in the pilot zone.

– Agglomeration of high technologies and industries. We should, with the support of central cities and key counties in this area, with industrial parks as the carrier, key industrial projects as the grasping point, high-tech industries as the main development direction, productivity advancing centers as the platform, focus on enhancing industrial concentration and correlation. We should also make great effort to intensify land utilization, extend the industrial chains, promote the concentration of enterprises and resource recycling, and build some high-tech industrial agglomeration areas that mutually supplement each other with distinct characteristics. Moreover, we should lay stress on building several high-tech industrial bases.
– Dominant agricultural agglomeration areas. We should propagate the technical pattern that integrates the breeding of livestock and poultry, utilization of biogas, plantation of fruits, grain, oil crops and vegetables, and intensive processing of agricultural products to develop ecological agriculture. On top of that, we should rely on distinct agricultural resources to build some dominant agricultural agglomeration areas specializing in growing, producing and processing quality agricultural products.
– Ecological protection. We should develop and promote recycling technologies, sewage and garbage disposal technologies. To this end, we should further study key resource recycling technologies and processes in organic silicon, copper processing, ceramics and manufacturing industries to build a system of key recycling technologies in the four industries. In addition, we should improve the living environment for urban and rural residents and carry out wastewater purification and waste disposal.

10.4.3 Five-River Basin Area

This region is the ecological defense and strategic hinterland of Poyang Lake Pilot Ecological Economic Zone. It is mainly designed to maintain ecological security in the lake basin, prevent the water quality in the region from deteriorating, control the concentration of sediment in rivers and lakes and gradually improve the quality of vegetation. We should selectively advance new industrialization and urbanization, cultivate some industrial clusters with regional features and competitive advantages, and build some distinct and efficient agricultural bases.

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Chapter 11
Conflicts Between Economic and Ecological Development in China's Pasturing Areas and Reasons for These Conflicts

Pan Jianwei and Gai Zhiyi

To survive and develop, humans need to acquire resources from the environment for material production so as to improve the material conditions for their living. The ecological environment constitutes the fundamental for the survival and development of human society, and the foundation for sustainable economic development. As the resources repository for China's economic development, and the birthplaces of many rivers in China, including the Yangtze River, the Yellow River and the Lancang River, pasturing areas not only make the strategic defense for national ecological security but also contribute significantly to economic construction. But for a long time, due to economic, natural, social and historical reasons, the ecological environment in China's pasturing areas have been deteriorating as grassland desertification, water loss, soil erosion, natural disasters, environmental pollution in urban areas and other ecological problems exacerbated. The ever-worsening ecological environment, to some extent, has bottlenecked the economic development in China's pasturing areas, not only hindering local economic construction, but also threatening the sustainable development of the country as a whole. Therefore, we need to, under the guidance of the scientific outlook on development, study how to achieve coordinated development between economy and ecological environment.

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11.1 Major Conflicts

Pasturing areas in Chin are both ecologically vulnerable and economically underdeveloped. Conflicts between economic development and ecological protection in these areas are quite intensive, which are mainly embodied in the following two aspects:

11.1.1 The Harsh Ecological Environment Bottlenecks Economic Development in Western China

Before the 1970s, degraded grassland in China only covered 10 % of the country's total. The proportion rose to 30 % in the 1980s and more than 60 % in the 1990s. Particularly, the size of severely degraded grassland reached 180 million hectares.[1] Moreover, the size of degraded grassland is increased by two million hectares every year, and the size of natural grassland is decreased by 0.65–0.7 million hectares year by year. Ningxia and Gansu reports the highest proportion of grassland degradation where degraded grassland takes up over 80 % of the country's total, followed by Xinjiang, Inner Mongolia and Qinghai where degrade grassland covers more than 50 % of the country's total.

More than a quarter of Chinese land now shows certain degrees of desertification. Grassland registers the largest proportion of desertification at 68 %, followed by farmland that covers 23 % and the land of other types that takes up 9 %. Over 95 % of the desertified land in China is in pasturing areas. Xinjiang has the largest desertified land, followed by Inner Mongolia, Tibet, Gansu, Qinghai and Ningxia.

As a result of China's "Go West" strategy, conditions in pasturing areas are somewhat improved. But on the whole, conditions are worsening. By 2005, China's western regions (excluding Tibet) saw the most severe and most extensive water loss and soil erosion, which reached 2.9374 million square kilometers and accounted for 82.6 % of the national total.[2] According to some statistics, the amount of soil influx into the Yangtze River and the Yellow River totals more than two billion tons every year. Land desertification has jeopardized the survival and development of more than 100 million people in China.

Pasturing areas in China are mostly isolated in inland regions where people's mindsets are relatively backward. The harsh ecological environment poses great difficulties for economic development.

[1] Liang Cunzhu, Zhu Tingcheng, Wang Deli, Lü Xinlong, Outlook on the Research of Grassland Ecology in China in the 21st Century, Chinese Journal of Applied Ecology, Issue 6 of 2002, Pages 743–746.

[2] Analysis of Agricultural Development in Western Regions in 2005, January 16 of 2007, www.china.com.cn.

First, the yield of forage in grassland drops, the grass grows low and sparse, toxic and harmful plants propagate and the quality of forage falls. Together, these severely hinder the development of animal husbandry, the dominant industry in pasturing areas. Since the 1980s, the yield of forage in main grassland in northern China has dropped by 17.6 % on average. Particularly, desert steppe has experienced the largest fall, which amounted to about 40 %. Typical grassland saw a decline of about 20 %. Provinces that registered a significant decline in forage yield included Inner Mongolia, Ningxia, Xinjiang, Qinghai and Gansu at 27.6 %, 25.3 %, 24.4 %, 24.6 % and 20.2 % respectively.

Second, the shortage of water resources deteriorates. Water resources are prerequisites for the construction of ecological environment, and also important premises for economic development. Most pasturing areas in China are severely short of water supply, leading to acute contradiction between water supply and demand is quite acute. Vegetation reduction, water loss and soil erosion constitute a vicious cycle, resulting in the destruction of water conservation function and exacerbating water shortage. The short supply of water resources is becoming increasingly acute. Consequently, much of the water for ecological purposes is diverted for other purposes, many rivers get dry, lakes shrink, and the level of underground water drops. The size of Ebinur Lake in Xinjiang, the largest fresh water lake in Northwest China, has contracted from 1200 km^2 in the 1950s to the present 500 km^2. More than 30 % of the lakes on the Qinghai-Tibet Plateau have dried into salt lakes or playas, with more than 14.8 billion cubic waters of water lost and the total size reduced by more than 300 km^2. Many lakes in the source region of the Yellow River are now dry. At the beginning of the 1960s, the ancient Juyan Lake covered still had a surface area of more than 300 km^2, with luxuriant reeds, rose willows and Euphrates poplars. Since the 1960s, dozens of reservoirs and water control projects have been built on the Black River. As a result, the Erginar River and the ancient Juyan Lake dried up. More than 0.85 million *mu* of Euphrates poplars, rose willows and narrow-leaved oleasters decayed. 5000 *mu* of grassland became desert, and many herdsmen were forced to move away and became ecological refugees.[3] The pasturing areas are now mostly in arid and semi-arid regions, where the annual precipitation is only about 200 mm, while the annual evaporation is more than 1200 mm, further exacerbating the water shortage in these areas. Moreover, in term of water resource development, inter-regional balance is ignored, the upper reaches and the lower reaches are not balanced, and surface water and ground water are disjointed. Therefore, the shortage of water resources becomes even worse.

Third, natural disasters become frequent. China's western regions inhabited by ethnic minority groups are ecologically vulnerable and prone to various natural disasters. Moreover, the environment is destroyed by human factors. As a result, ecological disasters become more frequent. These regions are geologically complicated with sound metallogenic conditions and rich reserves of various mineral

[3] Luo Hongbin, Brief Analysis of Major Ecological Problems in Western Regions, Inner Mongolia Forestry Investigation and Design, Issue 1 of 2007, Page 8.

resources. Exploitation of mineral resources plays a very important role in local economy, and has even become the pillar of economy in some pasturing areas. However, due to excessive exploitation, a large area of land has been damaged. In addition to land occupancy and damage, the negative impacts of mineral resources exploitation on the ecological environment also include extensive land subsidence, water loss, soil erosion, landslides, debris flows, drop in level of underground water and other geological disasters. As a result of excessive reclamation, destructive lumbering, excessive grazing, cultivation of steep slope lands and reclamation of wasteland by deforestation in the upper reaches of rivers, the capacity of forests and wetlands to store water and regulate floods has declined significantly. Flood disasters have increased and the ability to resist droughts dropped, resulting in exacerbated flood and drought disasters. Due to the significant reduction in natural forests, tree species in forests decrease and the structure of stand age becomes irrational, which in turn causes the ability of forests to resist interference to decline, the regulating ability of forest ecosystems to weaken and the ecological functions to fall. Excessive grazing, firewood chopping, Excessive reclamation and digging leads to severe destruction of grassland vegetation, changes in community structure, declines in quality and functions and ravage of rats and pests. In pasturing areas, the carrying capacity has declined in most grassland and the role of ecological defense has been increasingly weakened. Not only is the living quality lowered, but also huge economic losses are incurred, and the foundation of economic development is undermined.

11.1.2 Economic Interests Cause a Huge Pressure of Ecological Protection and Construction

The conflict between economic transformation and regional poverty has inflicted continuous damages to the ecology in pasturing areas. The vulnerability of ecological environment in China's western regions is not good for the survival and development of local population, but the emergence of ecological problems is largely attributable to lagging regional economic development. The per capita income in pasturing areas is only about 50 % of the national average, and over 70 % of the poor people who live below the survival line inhabit in these areas. As a result, the direct objective of economic development tends to be the improvement of people's material living standard. The demand for social products remains basic daily necessities, the demand for environmental quality is insufficient and economic development only pays attention to income increases. Therefore, when the conflict between economic income, product manufacturing and environmental protection arises, the latter is often sacrificed. In some poverty-stricken areas, environmental resources are sacrificed in exchange for basic survival supplies.

Lagging economy and ecological destruction are inter-related in practical economic operations. For a long time, people have failed to guide the economic development in pasturing areas with the idea of ecological economy which emphasizes coordinated development between economy and ecology. Instead, they only focused on the need to expand economic development, and ignored the carrying capacity of the ecosystem. Consequently, the normal operation of the ecosystem was disrupted and the socio-economic development became unsustainable. This is the ecological economic source for the lagging economy in China's pasturing areas. To develop economy in these areas, we must first attach great importance to the protection of local ecological environment.

As pasturing areas in China are mostly rich in various minerals, exploitation of mineral resources has invariably become the first choice for industrial development in these areas. In New Barag Left Banner and Old Barag Banner of Inner Mongolia, Tianjun County and Xinghai County of Qinghai and even the Mount Tungula area of Tibet which is 5000 m above the sea level, we can see mine exploitation in grassland. In the beautiful valley grassland of Yili, Xinjiang, there are several factories emitting black smokes into the sky. At first sight, we can tell that they are typical small coking plants. In addition to exploiting mineral resources, some pasturing areas have also introduced some high-energy-consuming and highly polluting enterprises. The pattern of development characterized by low threshold, heavy pollution and undue emphasis on economic benefit brought irreversible damages to local grassland ecosystem. According to a survey conducted by related authorities of Hulun Buir of Inner Mongolia, the lack of overall planning for coal mining in the city has led to disorderly exploitation in most coal mines. Coal gangue is deposited everywhere in small coal mines, not only occupying quality grassland, but also causing collapse pits in many places and leaving behind many scars in the mining areas. The size of collapse area in Baorixile of Inner Mongolia is nearly 18 km^2. It would take at least RMB 200 million to treat it, but the tax and profit from the mining is much lower than the treatment cost. In addition, the prospecting, mining and dressing of non-ferrous metals in grassland leave many trenches and pits. After prospecting, they are not recovered, causing much damage to vegetation. For instance, there are over 1600 trenches in a prospecting area in New Barag Right Banner of Inner Mongolia, and they destroy a large area of grassland.

There are several trends in the ongoing industrialization in pasturing areas of Inner Mongolia, Xinjiang, Qinghai and Tibet. First, some areas are desperately attracting investment. As a result, some polluting enterprises were built by taking advantage of the favorable situation. As industrialization in pasturing areas is mostly driven by local governments, some leaders don't have a scientific outlook on development and a right view of achievement. They are anxious to succeed, and consequently give a green light to whatever projects that come. Second, investment attraction and development are blindly conducted without clear ideas of reserve bases for mineral resources or scientific plans. Pasturing areas in China are home to rich mineral resources. But in the past, these resources were poorly prospected. Some areas are still undeveloped virgin lands. The endowment of underground resources is unclear. Many areas are engaged in investment attraction and development without detailed prospecting or scientific planning. Some investors are actually engaged in exploitation in the name of prospecting. Third, the project access threshold is too low without necessary environmental evaluation systems. Some local governments even serve as the umbrellas of polluting enterprises. As the industrial foundation was quite narrow in pasturing areas, local governments provided many preferential policies to boost industrial development, and even listed enterprises under key protection to keep them free of inspection by related authorities. Moreover, even if they find some problems with these enterprises, related authorities were not able to directly punish such enterprises. This, to some extent, leads to the absence of management. Fourth, the environmental awareness of mineral resource developers is not strong, and these enterprises lack the consciousness for grassland protection. As industrialization in pasturing areas is accelerated, the ground is dug in grassland to build factories and roads, leaving behind many scars. Wanton mining in grassland has given rise to many problems, including small size that leads to low utilization efficiency, mining rich ores while abandoning poor ores which causes low recovery rates of mining, rich resources mined by small mining enterprises or several mining enterprises sharing one mine, poor equipment and management, resource destruction and environmental pollution. Unlike reclaimed grassland that can recover within several years, grasslands that are polluted or destroyed by mining or factories can hardly recover in one century or several centuries.

11.2 Reasons

11.2.1 Cultural Reasons

Under the dominance of agrarian culture, people's understanding of ecological value experienced a long process. In 1934, the Commission on Rural Reconstruction of the Executive Yuan compiled the *Improvement of Agriculture in China*, in which grassland was treated as wasteland. It said that there were several million square kilometers of wasteland in China. After the founding of the People's Republic of China, grassland was called wasteland in the first constitution. In Clause 2 of Article 6 of the Constitution enacted in 1954, it said that "mines, rivers, state-owned forests, wasteland and other resources as stipulated by laws are collectively owned by all people." In Clause 2 of Article 6 of the Constitution promulgated in 1975, it said that "mines, rivers, state-owned forests, wasteland and other resources are collectively owned by all people." In Clause 2 of Article 6 of the Constitution issued in 1978, it said that "mines, rivers, state-owned forests, wasteland, other sea and land resources are collectively owned by all people." Grassland was not mentioned in any of these three constitutions. Surely, it was not left out due to negligence. Was it possible that grassland was categorized into "other resources"? But when we think it over, we can find that it was not the case. Several million square kilometers of grassland wouldn't be casually mentioned as part of "other resources." So obviously, in all these three constitutions, grassland was categorized into wasteland. This shows that the strong economic and ecological functions of grassland were ignored, and people's understanding of grassland-based nomadic cultures was insufficient.

11.2.2 Economic Reasons

The short-term behavior in pursuit of economic growth has resulted in the destruction of ecological environment. Local governments of pasturing areas hope to attract investment and advance inter-regional economic cooperation to boost local economic growth. Meanwhile, to meet the need of industrial upgrading, developed regions would transfer some low-tech, low value-added and high-pollution industries to the west. Due to excessive pursuit of growth, some local governments give the green light to some investments when they are fully aware of the resulting damage to the environment. Moreover, some local governments ignore the overall national interest for local interests, and develop some industries to gain economic benefits at the expense of ecological environment.

The irrational industrial structure, weak basis of animal husbandry, lagging industry, underdeveloped tertiary industry and low inter-industry correlation between industries in pasturing areas have severely hindered the coordinated development between ecology and an ecological economy, and lead to deteriorating ecological environment. First, animal husbandry lags behind and there is no sufficient impetus for restructuring. The basis of animal husbandry in pasturing areas is quite weak and traditional animal husbandry still accounts for a considerable proportion. The equipment used in for animal husbandry is technically backward. Other industries correlated with animal husbandry (such as the processing of animal products) still lag behind. Consequently, the propagation of ecological animal husbandry and advanced production techniques is quite slow, resulting in insufficient development and utilization of various resources in animal husbandry and related industries, severe waste of resources in animal husbandry and environmental destruction. Traditional extensive management still prevails in animal husbandry, leading to low individual livestock productivity. In addition, predatory management that puts more emphasis on yield than on investment is adopted. This has not only causes caused the waste and gradual exhaustion of natural resources and deterioration of ecological environment, but also the increasingly severe environmental pollution. Second, the industrial equipment is obsolete, the dominant industry is too simple, the industrial chain too short, the industrial distribution unreasonable, and the structural benefit too low. According to statistics, only 10–15 % of the equipment in enterprises in pasturing areas is up to the advanced level in China. Most enterprises are still using the machines manufactured in the 1960s or 1970s. The installed base of industrial equipment in pasturing areas is far behind that in China's eastern regions. Moreover, industry in pasturing areas is concentrated in resource exploitation and primary processing. The product structure is quite simple and a complete and reasonable industrial chain has yet to be established. This is not good for building an ecological industrial system. In addition, industrial structures in different pasturing areas are similar, which leads to the lack of economic distinctions, the failure to give full play to local advantages, excessive competition and repeated low-level construction at the same low level. This is not beneficial to establishing and improving a complete national industrial system, optimizing and upgrading industrial structure. Moreover, it will negatively affect the economic development of the whole country, lead to unreasonable allocation, tremendous waste of social resources and delay the development of pasturing areas. Third, the development of the tertiary industry is quite slow. The proportion of the tertiary industry is too low in the regional GDP of pasturing areas. It is about 40 %, which is far below 60 % in developed regions. The internal structure is unreasonable and the development is imbalanced. Traditional industries have a high proportion and play the dominant role. In contrast, new industries have a low proportion and are under-developed. Transportation, post, communications and catering develop at a rapid pace, causing serious environmental pollution. The development of finance, consultancy, patent propagation and other sectors that serve production and life is quite slow. This is not beneficial to the development of ecological economy, environmental economy or the improvement of ecological environment.

11.2.3 Political Reasons

Objectives seeking mere superficial and short-term achievements are against the profound and long-term objectives required for the protection of ecological environment in grassland. Excessive emphasis on "vanity projects" will lead to the ignorance of fundamental work, such as ecological protection in grassland.

Both deterioration and improvement of ecological environment in grassland are a process of gradual accumulation and a process from quantitative change to qualitative change. Once the ecological environment is severely destroyed and such destruction is irreversible, everything will be too late. Many authorities tend to emphasize the control and treatment of degraded grassland, while downplaying and skimping on the conservation of grassland that hasn't degraded. There is a common bias in the management of grassland resources, i.e. emphasizing construction, intensive and vigorous superficial work while ignoring protection, extensive and obscure fundamental work.

Currently, economic achievements are emphasized and encouraged in the performance assessment of officials. The key reason why successive governments have failed to curb grassland degradation and conserve the grassland is that a one-sided and short-term standard is applied for the performance assessment of officials, i.e. only assessing the economic achievements while ignoring the ecological achievements, only assessing the short-term achievements within the 5-year tenure while ignoring the far-reaching and long-term achievements. Officials are required to "make considerate achievements in their terms". As a result, they ignore the work that won't display its effect until after their terms. The present official performance assessment system easily leads to short-term economic behaviors, and local "achievements" cover up the huge social costs. It also ties the future of authorities and officials to some mechanical and metaphysical figures. This becomes the source of statistical corruption. The ecological environment in grassland often becomes victim to the competition of economic achievements.

11.2.4 Policy Reasons

The ecological resources in China are concentrated in the west while productivity and factors of production are mostly located in the east. This regional economic distribution poses a series of problems. Economic development requires natural resources. But the intensive utilization of natural resources will make the ecological environment in the west very vulnerable. The sustainable development of economy requires the restriction of the development of natural resources in the west, but such restriction will affect the pace of economic development.

Under the efficiency-first principle, the *Seventh Five-Year National Socio-Economic Development Plan* adopted in 1986 marked the full implementation of an imbalanced development strategy that gave priority to the development of eastern regions. As a result of this strategy, the eastern regions made outstanding achievements, and brought along the central and western regions. However, an obvious fact is that the east underwent comprehensive development of society, economy and ecological environment while the west paid a cost of increasingly vulnerable ecological environment for relative socio-economic development.

The imbalanced development strategy resulted in a simple industrial structure in pasturing areas, and a high proportion of raw materials, energy, mining and other upstream industries. Due to the imbalanced development strategy, pasturing areas have established an industrial structure dominated by resource-oriented and heavy industries. As economy grows faster and faster, the trend of "draining the pond to catch the fish" is even more obvious, and the ecological environment in pasturing areas is becoming even more vulnerable.

The "vertical specialization" of pasturing areas as raw material bases for eastern regions has not weakened since China kicked off reform and opening up. Instead, it has aggravated into "excessive vertical specialization".[4] The proportion of resource mining in regional GDP of pasturing areas is on the rise. But in eastern regions, this proportion is declining.

As the proportion of resource-oriented industry is too high and the technological content is too low, the structures of light industry, heavy industry, processing and products are highly similar. For instance, the proportion of mining and raw

[4] Liu Xiuguang, Policy Factors Contributing to Ecological Environment Vulnerability in Western Regions, Ecological Environment, 2007, Page 127.

materials industry in heavy industry is 50.4 % across China. But this proportion is respectively 83.0 %, 63.1 % and 87.0 % in Qinghai, Ningxia and Xinjiang. According to the structure similarity coefficient proposed by the United Nations Industrial Development Organization (UNIDO), when the similarity coefficient is larger than 0.5, the industrial structure should be adjusted. When the coefficient is larger than 0.8, the industrial structure is severely similar. Severe similarity of industrial structures will simply result in product surplus, lack of market competitiveness, poor economic and social benefits.

11.3 Conclusions

The new development pattern which pursues coordination between ecological and economic development, and the virtuous cycle between natural ecosystem and socio-economic system will inevitably require people to follow the rules of both the economic system and the ecosystem in socio-economic activities, address the combination of the impetus mechanism for the photosynthesis-based ecosystem with the impetus mechanism for the economic system based on inter-personal economic relations so as to form an impetus mechanism for the virtuous cycle between natural ecosystem and socio-economic system, build an ecological economic system in which the ecosystem and the economic system are integrated so that they can drive each other. This is the core issue for the virtuous interaction between ecology and economy. Therefore, economic development in pasturing areas must not come at a price of ecological destruction. Instead, we must embark on a road of sustainability, attach great importance to the protection of ecological environment, plan, implement and advance environmental protection simultaneously with socio-economic development, boost coordinated environmental protection and socio-economic development, achieve the virtuous cycle of the complex society-economy-environment system, and ultimately realize the optimal combination and organic unity of social, economic and ecological benefits.

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Chapter 12
Study of Regional Resource-Conserving and Recycling Industry Structure — A Case Study of the Cane Sugar Industry in Guangxi

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Guangxi is a latecomer region. 80 % of it is covered with mountains, 10 % with water and 10 % with farmland. Its economic competence, financial investment and technical resources are relatively weak in China. Therefore, it is not only necessary but also the only way out to build a regional resource-conserving and recycling industry structure. In this paper, we will, taking the local cane sugar industry as an example, analyze the approaches to build a regional resource-conserving and recycling industry structure from the perspectives of interactions between agriculture and industry, industry ecologicalization and recycling.

12.1 The Importance and Necessity of Developing a Resource-Saving and Recycling Cane Sugar Industry in Guangxi

12.1.1 The Cane Sugar Industry Is a Pillar Industry in Guangxi

That the cane sugar industry is the pillar industry of Guangxi can be proved by the following facts. First, 90 % of the sugarcane grown in Guangxi is used for

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processing. In the 2006/2007 milling season, 0.814 million hectares of sugarcane was grown in Guangxi, which accounted for over 90 % of the total acreage of canes in the region. Second, one out of every four of the provincial population works in the cane sugar industry. More than ten million people in Guangxi are employed in this industry, including over 12 million sugarcane farmers and more than 0.1 million sugar industry workers. The involvement of farmers and the number of people in this industry are both rare in China. Third, Guangxi's sugar yield has ranked first in China for 14 consecutive milling seasons since the 1992/1993 milling season, and its total sugar yield also tops the world's 10 largest sugar producers. In the 2006/2007 milling season, a total of 55.84 million tons of sugarcane was milled in Guangxi, and the sugar yield amounted to 7.086 million tons, accounting for 59 % of the national total of 11.994 million tons. The current processing capacity of sugar mills in Guangxi aggregates to 0.3 million tons of sugarcane a day, accounting for 36 % of the national total. The development of the cane sugar industry in Guangxi is now a barometer of China's sugar industry, and has an important effect on the sugar price in both China and the world. Fourth, the cane sugar industry has a far-reaching impact on regional economy. In the period when special product tax was levied on sugarcane, around half of the fiscal revenues of most counties and cities in sugarcane producing areas came from the cane sugar industry. In some places, this proportion was even as high as 80–90 %. After the special agricultural product tax was invoked, the cane sugar industry contributed 20–30 %, and even 50 % of the fiscal revenues in some places. The output of the cane sugar industry is now 15–20 % of Guangxi's GDP. Therefore, the advancement of a resource-conserving and recycling cane sugar industry is not only required to promote the rapid and sound development of the local cane sugar industry. It will also provide reference for building a resource-conserving and recycling economic industry system in Guangxi.

12.1.2 Development Demand of the Cane Sugar Industry

First, from the perspective of resources, the cane sugar industry must follow the recycling economy principles of reducing, reusing and recycling to maximize the utilization of sugarcane. Sugar is a material-intensive product and sugarcane is a quantifiable product. According to the *Eleventh Five-Year Industrial Development Plan of Guangxi*, several wood pulp paper and starch processing projects will be established in coastal areas, and silk industry will be developed in central and southern Guangxi. These industries may contend for farmland with the cane sugar industry. Therefore, the road to increase sugar yield simply by expanding acreage will become increasingly narrow. The current simple business development concept must be transformed, the industries on the industrial ecology chain must be accelerated and comprehensive utilization and deep processing must be developed for the sugar industry to rise to a higher development platform.

Second, from the perspective of industry, the cane sugar industry must extend its industrial chain and enhance its international competitiveness. China has the lowest tariff barrier for sugar among all WTO member countries. The average sugar tariff is 97 % in WTO member countries, 122 % in developed countries and 55 % in developing countries. In contrast, the sugar tariff of China is only 15 %. Particularly, many countries in the world provide various subsidies for their sugar industries. As a result, the sugar price in international markets is extremely distorted and fluctuates wildly. Moreover, China's sugar industry is faced with severe challenges from imported sugar. If we still use the traditional extensive sugar-making pattern in the international competition, and reduce the costs by lowering sugarcane prices, the road ahead from our sugar industry will become increasingly narrow. Also, it offers no way out to simply wait for protection policies. Instead, new growth patterns must be found. The development patterns adopted by Guangxi Guitang (Group) Co., Ltd. and Nanning Sugar Industry Co., Ltd. and achievements made have proved that only by building an ecological cane sugar industry can we really transform resource advantages into economic advantages.

Third, from the perspective of enterprises, increasing the comprehensive benefits of the cane sugar industry is the fundamental development method for sugar mills. While increasing the scale of sugar making, we can also cultivate six new industrial clusters, including paper-making, fiberboard-making, bioengineering, sugar deep processing, ecological agriculture and modern logistics. Taking paper-making industry as an example, bagasse paper-making technology in Guangxi is at the forefront around the world. However, the annual paper-making capacity is only 0.25 million tons. The cost of bagasse paper-making is only half that of wood-pulping, but its benefit is three times that of sugar making. Currently, the sugar bagasse in Guangxi totals over ten million tons a year. If 80 % of the bagasse is used, two million tons of paper can be made, and the resulting profits and taxes will be larger than those of sugar making.

Fourth, from the perspective of environment, comprehensive utilization and waste recycling can expand the development space for the cane sugar industry. At present, some sugar mills are small in size, scattered in distribution and low in efficiency. Moreover, they cause some pollution accidents from time to time and it costs a lot to control their pollution. Particularly, sugar making is concentrated in dry seasons of autumn and winter. So they cause very severe structural pollution. The discharge of the main pollutant, i.e. COD from sugar mills, accounts for 78 % of the total in Guangxi. This restricts the initiation of new industrial projects. We should, by establishing ecological demonstration sugar mills, recycle resources in an effective manner and significantly reduce pollutants. This will not only fundamentally solve the structural pollution problem, but also vacate the environmental capacity for major projects and pave way for large-scale industrialization.

12.2 Main Approaches to Develop a Resource-Conserving and Recycling Cane Sugar Industry in Guangxi

12.2.1 Inter-Industrial Development Approaches

12.2.1.1 Properly Handle the Proportions of the Cane Sugar Industry and Other Industries

According to the *2007 Analysis and Investment Consulting Report on China's Sugar Industry*, China's annual per capita sugar consumption is now about 8.4 kg, much lower than the world average of 24.9 kg. It is only about a third of the world's average, and lower than the average of 23.9 kg in Taiwan and 31.0 kg in Hong Kong. China is among the world's low-level sugar consumers. The low per capita sugar consumption and inadequate deep processing capacity constitute the primary contradictions in China's cane sugar industry, and also the main development obstacles. Therefore, it is necessary for the government to take more effective macro control policies and measures from a higher profile to boost sugar consumption and enhance the deep processing capacity. To this end, the key measure is to carry out technological innovation in the cane sugar industry.

12.2.1.2 Meticulously Make Green Designs for the Utilization of Cane Sugar Resources to Build a Resource-Conserving and Recycling Cane Sugar Industry System

Green design is the starting point for a recycling economy. To conserve resources, we must improve resource utilization and follow the recycling economy principle of reducing, reusing and recycling to maximize the utilization of sugarcane. To this end, we must, starting with the national economic industry system that represents the highest level and most macroscopic utilization and development of resources, apply the theories on recycling economy and implement recycling and green design for the utilization of sugarcane resources in Guangxi so as to build a resource-conserving and recycling cane sugar industry system. For instance, Guangxi is suitable for growing sugarcane and using biogas, where more than 39.21 % households in the rural area now use biogas. Therefore, the local cane sugar industry can be designed as follows: vigorously develop the breeding industry to advance the application of biogas, actively promote comprehensive biogas utilization technologies to advance cane sugar plantation, develop the sugar industry and the non-grain biomass energy industry to produce sugar and ethanol out of cane sugar, and support the breeding, biogas and sugarcane plantation with profits from sugar making and ethanol making to achieve a recycling and sustainable cane sugar industry.

12.2.2 *Intra-Industrial Development Approaches*

12.2.2.1 Conservation and Recycling Between Sugar Mills and Sugarcane Farmers

The relations between sugar making and sugarcane plantation should be properly handled to build a resource-conserving and recycling sugarcane plantation and processing industry chain.

Firstly, we need to improve comprehensive utilization. Brazil has made outstanding achievements in cane sugar making, waste liquid utilization and fuel alcohol production. Guangxi also takes the lead in China in building two industry chains for comprehensive utilization of sugarcane resources, i.e. sugarcane – sugar – molasses – alcohol – waste liquor – compound fertilizer and sugarcane – sugar – bagasse – pulp – paper. Sugar industry agglomeration areas consisting of new sugar-making, bagasse pulping, paper-making, bioengineering, sugar deep processing, ecological agricultural and modern logistics enterprises have taken shape. A recycling reproduction chain, i.e. sugarcane – sugar – molasses – alcohol – waste liquor – compound fertilizer – sugarcane has been built. Currently in Guangxi, sugarcane can be used in six processes, i.e. sugar making, breeding, paper making, alcohol making, fertilizer making and biochemical processing. It is calculated that the economic benefit produced by 1 ton of sugarcane in Guangxi can be up to RMB 1378, and the gross value of social products driven by RMB 1 yuan of sugar can be as high as RMB 16.3. In 2006, the output value of comprehensive utilization in Guangxi reached RMB four billion, about 20 % of the total output of the sugar industry. In total, the industry made 0.5 million tons of pulp and paper from bagasse, 0.2 million tons of alcohol and 0.3 million tons of compound fertilizers. As projected, the total output value of the sugar industry in Guangxi will reach RMB 45 billion by 2010. Particularly, the output value of sugar making and the output value of products made from comprehensive utilization of waste will stand at RMB 30 billion and 15 billion respectively, and the ratio of comprehensive utilization will be increased to 50 %. Currently, bagasse, molasses, white mud and other wastes are 100 % utilized in Nanning Sugar Industry Co., Ltd., and the output value of products made from comprehensive utilization of waste is now 30 % of the total output value of the company. Previously, the output value of sugar making in Guangxi Fenghao Sugar Industry Co., Ltd. was just a little over RMB 200 million. After a 50,000 t/a high-quality edible alcohol project was put into operation, the company's annual output value was increased by RMB 235 million. Moreover, the use of sucrose filter mud to produce organic fertilizers and compound fertilizers adds an output value of about RMB 100 million a year. Consequently, the profit of the company is more than doubled. In Chongzuo, sugarcane leaves and cane tips are used to feed beef cattle and cows, cow dung and bagasse are used to grow mushrooms, and mushroom mud is returned to farmland as a fertilizer, achieving a sugarcane – cattle/cow – mushroom circulation. Particularly, in Xiaxun Village, Xinhe Town of Jiangzhou District, a new industrial chain has been established in which sugar making acts as the leader, beef cattle/cow breeding as the link, edible fungus growing, dairy, meat processing and feed producing co-develop. Last year, the total income of the village reached RMB 2.15 million, and the per capita income was RMB 5000.

Secondly, we need to make good use of waste materials. From the perspective of ecological agriculture, agricultural wastes are carriers of certain material and energy, and a dislocated agricultural resource [8]. Thanks to the support of related authorities both at the national and provincial levels, 10 ecologically-friendly sugarcane growing demonstration counties have been set up in Guangxi to gradually propagate green sugarcane growing and processing technologies and a number of other technologies, including the application of healthy germchits, socialized service, ecological pig (cattle/cow, goat) breeding – biogas producing – sugarcane growing – lightning – fish breeding chain, improved cropping systems, application of agricultural machinery, returning of sugarcane leaves to farmland, soil improvement, biological control of diseases and pests, returning of waste liquor and filter mud from sugar mills to farmland in line with local conditions [9–15]. As a result of building ecologically-friendly sugarcane fields, farmers' income is increased, production and living conditions in rural areas are effectively improved and the use of pesticides is reduced. Biological resources are effectively and comprehensively utilized. A virtuous cycle of the ecological environment and the coordinated development of ecological, economic and social benefits are achieved in the sugarcane growing region. The success of the National Eco-Industrial Demonstration Park in Guigang (Sugar Industry) can be used as reference for other sugar mills. The ecological industrial development mode can be propagated in China's sugar industry for the sustainable development of sugar industry across China [16].

12.2.2.2 Conservation and Recycling in Sugar Mills

Technological innovation should be enhanced and a resource-conserving and recycling production chain should be built within sugar mills. First, we need to carry out transformation, and by transforming industrial products, develop new industrial areas, and re-incorporate the use value of products and resources into the socio-economic recycling system. The industrial chain of sugarcane production in Guangxi is gradually extended and widened, and the product portfolio gets diversified. In addition to traditional white and brown granulated sugar, raw sugar, refined sugar, soft sugar, oligose and other new offerings are added to the cane sugar product portfolio. By developing an ecologically-friendly sugar making industry, we are not only able to put an end to the structural and regional pollution haunted in traditional sugar making, but also restructure the traditional sugar making industry and protect the environment in the process of development to achieve both economic development and environmental protection. This conforms to the world economic development trend. Second, we need to reduce energy consumption, and by vigorously reducing energy consumption and enhancing management, transform the use of key energy from one-off utilization to repeated utilization. Before 1998, there were 112 sugar mills in Guangxi. But these mills were small in size and produced severe structural pollution. As a result of restructuring and reorganization in recent years, 18 small sugar mills that didn't have sugarcane materials were shut down, and 15 large sugar groups were established. The 15 groups now own 68 sugar mills, accounting for 80 % of the sugar mills in Guangxi. In the 2004/2005 milling season, they produced 4.78 million tons of raw sugar, accounting for 90 % of the total in Guangxi. Thanks to the reorganization, energy consumption and cost are both reduced by 15 % [5, 7].

12.3 Empirical Analysis of Developing a Resource-Conserving and Recycling Cane Sugar Industry in Guangxi

The cane sugar price and sugarcane growing cost are both relatively high in China. Through industrial ecologicalization and inter-industrial recycling, we can effectively reduce the costs and increase the international competitiveness of cane sugar products. Next, the reduction of fertilizer cost for sugarcane growing will be used as an example.

12.3.1 Cost of Sugarcane Growing in Guangxi

Table 12.1 indicates that the sugarcane growing cost rises very fast in Guangxi. Particularly, the cutting and fertilizer costs grow faster and take up larger proportions. The sugarcane growing cost can be reduced mainly through technological innovation in cane seeds, cultivation, management and machinery. The fertilizer and pesticide costs can be significantly lowered by developing ecological agriculture.

12.3.2 Approaches to Reduce Fertilizer Cost in Sugarcane Growing Industry of Guangxi

12.3.2.1 Improve the Overall Utilization of Sugarcane Tips

In 2006, the acreage of main crops in Guangxi totaled 6.455 million hectares, and the yield of crop stalks was about 45 million tons. Particularly, 12.12 million and 24.24 million tons of stalks were respectively used as livestock feed and household energy in rural areas, accounting for 27 % and 53 % of the total. The remaining stalks were mainly used as industrial materials (such as paper making) and

Table 12.1 Cost of sugarcane growing in Guangxi (75 tons of sugar per hectare)[a]

	Shangsi county in 2002		Guangxi in 2002		Jiangzhou county in 2006		Guangxi in 2006	
	RMB yuan	%	RMB yuan	%	RMB yuan	%	RMB yuan	%
Soil preparation	900	10.2	900	10.5	1200	10.9	1200	11.1
Tilling	600	6.8	525	6.2	750	6.8	656	6.1
Sugarcane seeds	1500	17.0	1050	12.3	1450	12.9	998	9.2
Fertilizers	2430	27.6	2685	31.5	2910	26.4	3215	29.8
Pesticides	675	7.7	675	7.9	750	6.8	750	6.9
Management	450	5.1	450	5.3	225	2.0	225	2.1
Cutting	2250	25.6	2250	26.4	3750	34.1	3750	34.7
Total	8805	100	8535	100	11,010	100	10,794	100
Cost per ton of cane sugar	117.4		113.8		146.8		143.9	

[a]Data source of sugarcane growing cost in Guangxi: Dissertation of Wang Weizan (2004), Si Wei (2005) and Wei Yanbiao (2007). As Shangsi County and Jiangzhou are adjacent and primary sugarcane growing regions, the sugarcane growing cost of Guangxi in 2006 was deduced from the aforementioned 3 costs, with part of the data modified according to expert comments. Data source of sugarcane growing and animal husbandry in Guangxi: 2007 Guangxi Statistical Yearbook. Data source of biogas development in Guangxi: 2007 Guangxi Statistical Yearbook, and some data is provided by Guangxi Rural Energy Office
Unit: RMB yuan

materials for fertilizers. In the year, the acreage of sugarcane in Guangxi reached 0.838 million hectares. The sugar cane and cane tip yields reached 59.248 million tons and 14.812 million tons respectively. The cane tips used as household energy in rural areas took up 53 % of the total. This means that 7.85 million tons of cane tips were directly burned. If these 7.85 million tons of cane tips were all used as material for biogas production, they would not only provide several hundred million cubic meters of biogas, but also produce over 20 million tons of fermented liquid and residue that could be used as quality organic fertilizers. Consequently, the application of organic fertilizers to each hectare of sugarcane field could be increased by 22.5–30 tons, and the fertilizer cost for each ton of sugarcane could be reduced by RMB 7.5–20.

12.3.2.2 Increase the Utilization Rate of Waste Liquor as a Fully Organic Liquid Fertilizer

In 2006, 55.84 million tons of sugar cane was crushed milled, producing 7.086 million tons of sugar in Guangxi. The output value of products made from comprehensive utilization of wastes from sugar industry totaled RMB four billion, accounting for 20 % of the total output value of the sugar industry. 0.5 million tons of paper was made from bagasse. Also, 0.2 million tons of alcohol and 0.3 million tons of compound fertilizers were produced. Currently, except for a small quantity of solid waste that is not used to make compound fertilizers in a few sugar mills, most solid waste is recycled. But in term of liquid waste, there are still five million tons that are not fully recycled. According to the latest research made by Li Yangrui et al (2008)[22], if waste liquor is applied to sugarcane field at a rate of 75 t/ha, the economic benefit will be increased by RMB 5792–6736/ha. If this technology is popularized throughout Guangxi, a direct economic benefit of RMB 386.133–449.067 million will be added and the fertilizer cost will be reduced by RMB 6.9–8.0 per ton of sugarcane.

12.3.2.3 Accelerate the Development of Animal Husbandry in Main Sugarcane Growing Areas

In 2006, the per capita sugarcane yield in Guangxi reached 1199 kg. The top five cities were Chongzuo (7384 kg), Laibin (3577 kg), Fangchenggang (2894 kg), Liuzhou (1787 kg) and Nanning (1437 kg). Sugarcane growing in Guangxi is mainly concentrated in these cities.

In the same year, the per capita meat output reached 90 kg in Guangxi. The last five cities were Fangchenggang (60 kg), Chongzuo (64 kg), Liuzhou (73 kg), Guigang (74 kg), Nanning and Baise (76 kg). The top city was Hezhou (154 kg), which was 2.4 times the output of Chongzuo. Animal husbandry relatively lags behind in Fangchenggang, Chongzuo, Liuzhou, Guigang, Nanning and Baise.

The development of animal husbandry is one of the effective ways to increase farmers' income, and also an important source of quality organic fertilizers for farming. But in Guangxi, sugarcane is mostly grown in regions where animal husbandry is least developed. As a result of small supply of organic fertilizers, the cost of outsourcing fertilizers for sugarcane growing is increased. If animal husbandry in areas where sugarcane growing is concentrated reached the average level of Guangxi, the output of organic fertilizers could be increased by a quarter or even a third. Consequently, the application of organic fertilizers to each hectare of farmland in Guangxi could be increased by around three tons. Excluding the added cost for fertilizers, the fertilizer cost for each ton of sugarcane could be reduced by RMB 1–2.

12.3.2.4 Increase the Rural Household Biogas Coverage Rate

At the end of 2006, there were 2.7248 million household biogas digesters in the rural areas of Guangxi, covering 27.6 % of the rural households. They produced 1.133 billion cubic meters of biogas and 85.994 million tons of quality organic fertilizers each year. Guangxi is located in a tropical and sub-tropical zone, where there are a wide range of plants that grow rapidly, and biogas digesters can produce biogas throughout the year. This is favorable for the development of biogas. If the rural household biogas coverage rate were increased by 10 % each year, 31.02 million tons of quality organic fertilizers would be added on an annual basis and consequently the application of fertilizers to each hectare of farmland would be increased by 4.8 tons. Excluding the added cost for fertilizers, the fertilizer cost for each ton of sugarcane could be reduced by RMB 1.5–3.

In 2006, the rural household biogas coverage rate was 27.6 %. But it varied greatly from city to city. The highest level could be up to 60 % while the lowest level was less than 10 %. It was the same case in areas where sugarcane growing is concentrated. For instance, the rural household biogas coverage rate was 54.0 % in Chongzuo. But in Laibin, Liuzhou, Nanning and Fangchenggang, the rate was respectively 28.1 %, 30.6 %, 38.6 % and 20.9 %. The rate was only 10.9 % in Guigang and 9.5 % in Beihai. The imbalanced biogas development resulted in differentiated fertilizer costs for sugarcane growing.

12.3.2.5 Conclusions

By comprehensively using cane tips, fully utilizing waste liquor as an organic fertilizer, developing animal husbandry and biogas digesters in main sugarcane growing regions, the fertilizer cost for each ton of sugarcane can be reduced by RMB 17–33 in Guangxi, and the production cost for each ton of sugarcane can be lowered by 11.8–22.9 %. This will significantly reduce the cost and increase the benefit.

12.4 Inspirations and Suggestions for Building a Regional Resource-Conserving and Recycling Industry

Reducing the sugarcane growing cost is an inevitable choice for the sustainable development of the cane sugar industry in Guangxi. However, such cost reductions should not come at the expense the interests of sugarcane farmers. By developing ecological agriculture, recycling cane sugar industry and a sugarcane growing – animal husbandry –biogas industrial chain, we will not only reduce the cost of outsourcing fertilizers for sugarcane growing to bring sound economic benefits, but also recycle the waste, reduce the environmental pressure and yield significant social and ecological benefits.

Hence, we have at least two inspirations. First, making the most of resources constitutes the maximum resource conservation. To save resources, we must increase resource utilization and recycle as much as possible. Only in this way can we make the most of resources and conserve resources to the greatest extent. Second, we should start with the whole regional economic system for conservation. Green design is the starting points of a recycling economy. Irrational economic systems represent the biggest waste of resources. So we must start with the macroeconomic system, apply theories on recycling economy and implement green design for resource utilization in the region so as to build a resource-conserving economic system.

The key to building a regional resource-conserving and recycling industry is to implement the principles and requirements of resource reducing, reusing and recycling in the production, exchange, allocation and consumption links throughout the whole regional socio-economic development process, including material and non-material production, so as to increase the contribution rates of all factors of the whole society. The core requirement is to, from the perspectives of recycling economy and ecological economy, from inter-industrial, intra-industrial, inter-business and intra-business views, and from the view of building a regional resource-conserving and recycling economic system, proceed with the innovation of resource utilization, the conservation of energy, water, material and land, and analyze the specific patterns of resource-conserving and recycling first, secondary and tertiary industries in the region so as to build a new resource-conserving and recycling regional economic system.

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Part III
Empirical Study of Ecological Economy

Chapter 13
Foreign Trade Deficit in Term of Resource-Environment and Application of Trade Practices for Achieving Environmental Goals

Hu Tao, Wu Yuping, Shen Xiaoyue, Mao Xianqiang, Li Liping, and Yu Hai

13.1 China's Foreign Trade Increases Rapidly While Surplus Keeps Expanding

China's foreign trade has increased rapidly and made extraordinary achievements, thus becoming one of the three major engines that drive the country's economy. Since the kickoff of the reform and opening up, particularly since China's accession to WTO in 2001, the country's foreign trade has been increasing by 20–30 % annually, the rapidest growth in the world. In 2006, China's total import and export of merchandise amounted to US$ 1.77 trillion, up 24.5 % over 2005, and the trade surplus reached US$ 150 billion. According to WTO, China's total foreign trade was expected to exceed that of Germany by the end of 2007. Consequently, China would become the world's third largest economy after the U.S. and EU. Currently, China's trade surplus exceeds US$ 200 billion every year. Its foreign exchange reserve is now up to US$ 1.3 trillion, which represents the world's largest stockpile of foreign exchanges. In addition, foreign direct investment in China has increased at a pace, which exceeded US$ 50 billion in 2003 and reached US$ 61.3 billion in 2006, making China the world's largest foreign investment destination.

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13.2 China's Foreign Trade Has a Surplus in Term of Money, But Some Industries Report a Deficit in Term of Resource-Environment

The balance of international trade can be calculated from the perspective of economic value, weight or size. Currently, trade is only measured from the perspective of value rather than resources. The value of trade merely covers the nominal value of commodities or service products in market, but ignores the costs of resource consumption and environmental pollution. The environmental and trade expert panel from the Ministry of Environmental Protection explored how to calculate China's foreign trade from the perspective of resources and environment.

Trade is the value exchange process of commodities or services. It is also a carrier that carries certain economic value, resource consumption and environmental protection. The production and consumption of both commodities and service products would consume resources and discharge pollutants. Therefore, imported and exported products in foreign trade imply a certain amount of resource consumption and pollutant discharge incurred in the process of production and consumption, which in turn affects the local resource-environment. The impact of imported and exported products on local resource-environment can be quantitatively calculated.

From the perspective of flow, the contribution of exporting one ton of locally produced products to the local resource-environment is defined as negative, while from the perspective of production and substitution, the contribution of importing one ton of corresponding products to the local resource-environment is defined as positive. If the difference between the export value and the import value is larger than zero, it is a surplus. Contrarily, if the difference between the export value and the import value is smaller than zero, it is a deficit. And, if the difference is zero, it is a balance. For instance, in a place in China, to produce one ton of exported steel, 500 m^3 of water are consumed and 0.2 ton of SO_2 is emitted. The contribution to China's resource-environment is defined to be -500 tons of water resource and -0.2 ton of SO_2. If a place imports one million tons of steel and exports two million tons of steel in a year, from the perspective of resource-environment, the deficit is five billion m^3 of water and 0.2 million tons of SO_2.

It can also be defined from the perspective of stock. If the foreign trade somewhat improves and has a positive impact on local resource-environment, it is a surplus in term of resources. If the foreign trade exacerbates and has a negative impact on local resource-environment, it is a deficit in term of resources. It's just like the foreign trade that increases foreign exchange reserve is a surplus in term of trade value, and the foreign trade that reduces foreign exchange reserve is a deficit in term of trade value.

The primary result of study conducted by the environment and trade expert panel from the Ministry of Environmental Protection shows that China's foreign trade is a deficit in term of resources, although it is a surplus in term of trade value. For a long time, the extensive foreign trade growth pattern that is driven by resource-intensive products and quantity constituted a considerable proportion in China's foreign trade. This pattern now accelerates China's extensive and unsustainable production and consumption mode, exacerbates the pressure of resource-environment and poses a daunting challenge to environmental protection in China.

The result of calculation with the DRC-CGE model of the Development Research Center of the State Council shows that in China's total emissions of SO_2 during the 10th Five-Year-Plan period, if the differences between the production structure and the trade structure were left out, China's SO_2 deficit caused by foreign trade was about 1.5 million tons per year, which accounted for nearly 6 % of China's annual total SO_2 emissions. If the differences between the production structure and the trade structure are taken into consideration, as China's foreign trade grows much faster than production, the SO_2 deficit caused by foreign trade will be significantly higher.

While boosting economic growth, China's current trade growth pattern also brings a huge pressure to the resource-environment. In the face of the huge achievements made in increasing foreign trade and the resource restrictions for domestic economic growth, the government should pay much attention to the present cost of resource-environment for trade growth, and explore a sustainable trade growth pattern.

13.3 Primary Reasons for China's Foreign Trade Deficit in Term of Resources

According to comprehensive analysis, China's foreign trade has a deficit mainly due to the following three reasons.

13.3.1 The Import and Export Structure Is Unreasonable

Foreign trade has been a major pillar of China's national economy. It used to be an important way to earn foreign currency. To pursue trade benefits, China's foreign trade has, for a long time, been driven by quality and grown at the cost of resources and environment. The foreign trade structure was unreasonable, featuring large export of resource-intensive and high-polluting products and small export of resource-efficient and less-polluting products, large export of low-end products and small export of high-end products, large export of traditional products and small export of high-tech products, large export of goods and small export of services. In recent years, as a result of increasingly intensified macro control, China's foreign trade structure has been adjusted and optimized to a certain extent, with the proportion of high-tech products in export rising steadily.

Specifically, in China's export, high-polluting and resource-intensive industries have a large percentage in the traditionally competitive industries, including textile, leather and leather products, chemical, food, agricultural products, cement, building materials, coke and steel. In the international industrial division system, China is at the low end. Over 55 % of China's trade comes from processing trade, and 90 % of the high-tech products are exported in the form of processing trade. Amongst, over 95 % of staple commodities at the top of the export list of high-tech products, such as laptops, plasma color TV sets and DVD players are exported in the form of processing trade. China's import is mostly high-tech products and service products, such as pollution-free service products like finance and insurance. China's export of services is significantly smaller than goods. In 1997–2003, its service export grew at an average rate of 11.3 %. In the same period, goods export grew by 30.2 % on average each year. In 2005, China's commodity export was among the world's top three while the export of service products ranked the 8th in the world.

Preliminary calculations indicate that during the 10th Five-Year-Plan period, China's export of products causing high SO_2 pollution accounted for 40 % of total export, and the export of products causing high COD pollution took up 44 % of total export.

A study of the World Bank shows that the structural contribution of seven major polluting industries in the world has remained almost unchanged in the past five decades, except that these industries were relocated from one place to another. This suggests that pollutants in China come not only from domestic production and consumption, but also from production and consumption all around the world.

13.3.2 The Environmental Efficiency of Exported Products Is Quite Low

The average resource consumption and pollution intensities are both high for China's exported products (including goods and service products), and low for imported products. Currently, the pollution intensity per unit of most products exported by China is higher than that of developed countries.

Let's take the textile industry as an example. To produce 100 m of cotton cloth, China needs to consume 3.5 tons of water and 55 kg of coal, discharge 3.3 tons of waste water, and generates 2 kg of COD and 0.6 kg of BOD_5. The textile industry discharges 1.53 billion tons of waste water a year, ranking the 5th among the 40 industries, and its annual discharge of COD in industrial waste water ranks the 4th. In addition, a rough estimate of environmental damage caused by the coke industry shows that in 2003, 2004 and 2005, China's coke output reached 178 million tons, 206 million tons and 243 million tons respectively. If the environmental damage caused by the waste water discharged by coking industry is RMB 76 per ton, the environmental damage resulting from coke would reach RMB 13.528 billion,15.656 billion and 18.468 billion respectively, accounting for about 0.3 % of the industrial added value in respective years. In Shanxi, China's primary coke-producing province, the environmental damage caused by coke production accounts for about 5 % of the province's industrial added value. China's energy consumption and water consumption for each ton of steel is about 5–10 times the world's advanced level. In addition, China is becoming the world's largest steel exporter. This means that while exporting steel products, China is sacrificing its environmental interests.

13.3.3 The Export Grows Rapidly

China's export is now growing at a rate of 20–30 % annually. Such a rapid increase significantly boosts the growth of relevant industries, particularly high-polluting and energy-intensive industries.

According to the primary calculation with the DRC-CGE model, during the 10th Five-Year-Plan period, if the differences between production and export structures are ignored, the export growth contributed about 20 % of the SO_2 emissions. Changes in the export structure contributed 5.5 %, but the productivity increase contributed −5 %. So only the productivity increase reduced the emissions of SO_2.

13.4 Reduce and Eliminate the Deficit in Term of Resources and Improve the Resource Conditions in China

In the face of serious resource challenges, the State Council recently adopted a series of measures to speed up the transformation of export growth patterns. On September 14, 2006, five ministries and commissions, including the Ministry of Finance, jointly issued the *Notice on Adjusting the Export Tax Rebate Rates of Some Commodities and Supplementing the Catalogue of Prohibited Commodities in Processing Trade*. This was another move that China made, following the reduction of export tax rebate rates for all commodities at the beginning of 2004, to further lower or even abolish the export tax rebates for high-polluting, high-energy-consuming and resource-dependent products, and supplement the list of these products to the catalogue of prohibited and restricted products in processing trade. As a result, the over-rapid growth of export of high-pollution, high-energy-consumption and resource-intensive products was significantly checked. The *Report on Chinese Foreign Trade Development (Autumn 2006)* indicates that China's export of crude oil, petroleum products, coal and unwrought aluminum respectively fell 21.8 %, 21.1 %, 11.9 % and 5.8 % in the first three quarters.

Adjustments to trade policies on high-polluting, high-energy-consuming and resource-dependent products have achieved initial success in controlling the over-rapid growth of these products and reversing the foreign trade deficit in term of resources. However, trade restructuring is a long-term and difficult task, which calls for concerted efforts of many parties and integrated trade and environmental measures to manage import and export. In this regard, we need to make further study and explorations. Particularly, we need to, from the perspective of environmental protection, further reverse the foreign trade deficit in term of resource-environment and improve the resource-environment conditions in China.

After a preliminary study, the WTO expert panel with the Ministry of Environmental Protection suggested that an adjustable "valve" of environmental protection should be added in the import-export process to restrict the export of resource-intensive products and encourage the import of such products. The "valve" can be set up in the following three links: import and export environmental tariffs, market access and exit as well as investment.

13.5 Employ Comprehensive Trade Measures to Strengthen Environmental Protection and Facilitate the Transformation of Economic Growth Patterns

The transformation of trade growth patterns is crucial and indispensable for China to implement a resource-efficient, environment-friendly and social-harmonious sustainability strategy. We should, in the critical period for historical transformation in environmental protection, optimize trade growth through environmental protection, strengthen the protection through comprehensive trade measures, promote sustainable trade, reduce and reverse foreign trade deficit in term of resource-environment, transfer the effect of trade on environmental protection to production and consumption via market pricing mechanisms so as to change the existing unsustainable production and consumption patterns and eventually transform the economic growth patterns in an all-round manner.

Relevant studies show that at present China should employ import and export tariffs, market access and exit as well as investment measures to strengthen environmental management, optimize trade growth through environmental protection and facilitate the transformation of trade growth pattern. The studies also provide the following detailed policy proposals.

13.5.1 Expand the Scope of Export Tariffs and Increase Environmental Tariffs for Export of High-Polluting Products

It is suggested that the State Council should, based on the existing commodity catalogue for export tariffs, consider expanding the scope of export tariffs, and specifically increase environmental tariffs for export of high-polluting products in high-polluting industries, such as textile, chemical, paper making and food processing.

It is suggested that the export tariffs should be levied according to the quantity and weight of exported commodities. This proposal aims to restrict the export volume of products of low value, reverse the predicament in which China's foreign trade relies heavily on volume, control the export of commodities that lead to severe environmental pollution, excess production capacity, frequent trade frictions and whose prices are severely slashed for export so as to reduce the foreign trade deficit in term of resource-environment and facilitate the optimization of product structure and industrial upgrading.

When levying export tariffs, we should use the practice and experience of specific funds for textile to establish a special environmental protection fund with the environmental tariffs. The fund can be used for environmental protection facilities in relevant industries, technical transformation and clean production so as to comprehensively enhance the competitiveness of related industries. Moreover, a fund can be established to award environment-friendly companies engaged in foreign trade and provide them with subsidies for ISO14000 certification, environmental certification and clean production auditing.

13.5.2 Design and Implement a Market Access and Exit System for Environmental Protection

The Ministry of Environmental Protection should, in conjunction with the Ministry of Commerce, the State Administration of Taxation, the General Administration of Customs, the National Development and Reform Commission, the General Administration of Quality Supervision, Inspection and Quarantine, the Ministry of Land and Resources and the State Forestry Administration, thoroughly and systematically study and establish a market access and exit system for resource-environment protection. They can take the following measures to strengthen the application of resource-environment protection policies from the perspective of market exit.

1. Expand mutual recognition of environmental labeling systems with other countries, and encourage the export of environmentally-labeled products by employing different tariff rates, rebating export tariffs, providing direct subsidies and incorporating them into government procurement plans.
2. Establish a "white list" for environment-friendly enterprises, and encourage listed enterprises to export by rebating export tariffs and providing preferential customs clearance treatment; the list should include enterprises that are awarded the title of environment-friendly enterprises and have passed the certification of environmental management systems; enterprises should be encouraged to enter the "white list" by incorporating them into government procurement plans, providing them with direct subsidies and preferential tax rates.

3. Establish a “black list” for enterprises according to the database of major polluting enterprises, and restrict their export by levying environmental tariffs and even ban their export.
4. Adopt industrial policies more beneficial to resource-environment protection and restrain high-polluting, high-energy-consuming and resource-dependent industries through quota, permit, ban, price limit, credit and other trade control measures.
5. Restrict the investment of resource-intensive industries in China and encourage them to invest overseas.
6. Extend the environmental impact assessment (EIA) system to the area of international trade, apply different levels of EIA measures to trade agreements, trade policies and even specific orders, and carry out classified management, including banning import and export, restricting import and export as well as encouraging import and export according to the EIA results.

13.5.3 Raise the Environmental Access Thresholds for Foreign Direct Investment and Guide Overseas Investment Activities of Chinese Enterprises

The Ministry of Environmental Protection should, by adjusting the industrial structure and regional distribution of foreign direction investment on the national macro level, fundamentally solve environmental problems brought by foreign direct investment. Specific measures include the following:

1. Propose modifications to the existing *Catalogue for the Guidance of Foreign Investment* as early as possible, and expand the scope of prohibiting and restricting foreign investment by strengthening environmental management and raising the environmental access thresholds for foreign investment.
2. Specifically define and refine the environmental requirements in the *Provisions on Guiding the Orientation of Foreign Investment*, and put forth detailed standards and scope of applicability as supplementary articles of the *Provisions on Guiding the Orientation of Foreign Investment*.
3. Leverage the EIA tools of environmental authorities to strictly examine projects funded by foreign direct investment with huge potential environmental risks.
4. Create a green investment guide as soon as possible.

13.5.4 Improve Waste Import Policies to Effectively Prevent Environmental Risks Arising from Waste Trade

The Ministry of Environmental Protection should enhance the cognition of the strategic significance of importing waste that can be used as materials, address the critical period for historical transformation in environmental protection, improve laws and policies on importing waste, strengthen environmental management for the disposal of imported waste, beef up the supervision and strictly enforce relevant laws. Specific proposals include the following:

1. Improve an inter-ministerial coordination mechanism for the environmental management of waste import and enhance the policy coordination between environmental protection, customs and other relevant authorities. Environmental protection authorities should vigorously establish and improve relevant laws and policies and intensify enforcement. Customs authorities should take the lead in cooperating with other authorities to crack down on illegal waste trade.
2. Incorporate waste import into local EIA, and veto any import trade that fails in the EIA.
3. Levy pollution discharge fees on the import of waste which may cause environmental impacts. The pollution discharge fee should be borne by importers which should list the compensation for environmental damages into their costs.
4. Enhance environmental monitoring of import, distribution, re-processing and reuse waste, strictly enforce relevant laws, make sure that the imported waste flows to enterprises capable of processing and reusing it and carry out effective environmental management for imported waste through the whole process.
5. Leverage the *Basel Convention* and other international conventions to control illegal waste trade. Strengthen the study of relevant international laws and conventions and employ legal means to safeguard China's environmental security in waste import.

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Chapter 14
Reduce Agricultural Diffused Pollution Through Water Conservation: Inspirations of Optimal Model of Water for Agricultural Use

Zhang Zheng

14.1 Model Characteristics

The optimal model of water for agricultural use was created by Israeli economists N. Becker and N. Zeitouni and the U.S. economist David Zilberman according to the actual conditions of agriculture (farming) in Israel. Details of the model are as follows (N.Becker et al. 2000).

Characteristics of the model:

1. Water for agricultural use comes from underground water.
2. The extraction of underground water will, on the one hand, lead to the level of underground water to fall and the cost of water extraction to rise, and on the other hand, cause irrigation water that is not effectively used to sink into the ground with pollutants from surface soil layer, which in turn will pollute underground water. The pollution of underground water has a negative impact on agricultural production. Therefore, we must consider the optimal usage of water for agriculture and water quality (pollution caused by the use of water in agriculture).
3. The optimal water usage of the whole society is different from that of individuals. The difference between them constitutes the optimal tax rate.
4. The water level and water pollution level are functions of time. Therefore, they must be analyzed dynamically.

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14.2 Model Building

14.2.1 Model Assumptions

The model assumptions include the following:

1. There are N farmers of the same conditions in a region. They grow the same crops and are price takers in market (they don't have the ability to affect market prices individually).
2. In the production, the fixed input is land and the variable input is water.

14.2.2 Model Functions

The production function is

$$Q_i(t) = f[hw_i(t), E(t)] \tag{14.1}$$

In Formula (14.1), $w_i(t)$ is the amount of water used by Farmer *i in year t*, $t = 1, \ldots, N$; *h is the irrigation efficiency coefficient,* $0 < h < 1$. Therefore, hw_i represents the amount of water efficiently used by crops, and the remaining amount $(1\text{-}h)w_i$ is the lost water. $E(t)$ represents the stock of pollutants in the underground aquifers in year t. As the pollution has a negative impact on production, the larger the stock of pollutants, the lower the crop yields.

The annual water level change in underground aquifers is:

$$\cdot S\,(t) = R(t) - \sum_{i=1}^{N} hw_i(t) - aS(t) \tag{14.2}$$

In Formula (14.2), R (t) represents the annual water supply to underground aquifers; a represents the annual natural loss (evapotranspiration) rate of water in underground aquifers; $S(t)$ stands for the underground water level in year t.

The annual pollutant change in underground aquifers is:

$$\cdot E\,(t) = \sum_{i=1}^{N} (1 - h)mw_i(t) - bE(t) \tag{14.3}$$

In Formula (14.3), m represents the pollution rate of each unit of extracted water for agricultural use and b stands for the annual attenuation rate of pollution stock.

$c\,(S)$ represents the unit cost of extracted water and $(c(S)$ the decreasing function of underground water level; the higher the underground water level is, the lower the unit cost of extracted water will be; $c' < 0$ (monotone decrease) and $c'' > 0$ (convex function). $P(t)$ represents the price of products, so the profit (gross margin) of all N farmers in the whole society would be:

$$\Pi_R(t) = \sum_{i=1}^{N} [P(t)Q_i(t) - c(S)w_i(t)] \tag{14.4}$$

The profit of individual farmer is:

$$\Pi_F(t) = [P(t)Q_i(t) - c(S)w_i(t)] \tag{14.5}$$

If the discounted value of total net social benefits is optimized, we can get

$$\max_{w_i(t)} \int_0^{\infty} e^{-rt} \left[\sum_{i=1}^{N} [Pf(hw_i, E) - c(S)w_i] \right] dt \tag{14.6}$$

Under the premise of constraint Formulas (14.2) and (14.3), from Formula (14.6) we can get the optimum water extraction of the whole society and optimal water quality. The condition to maximize Formula (14.6) is:

$$P\partial f/\partial w_i(h{*}w_i, E) - c(S) - \lambda_1{*}h - \lambda_2{*}m{*}(1-h) = 0 \tag{14.7}$$

In Formula (14.7), λ_1 and λ_2 respectively stands for the shadow prices of water amount and water quality. Under the premise of constraint Formulas (14.2) and (14.3) (both formulas equal 0), from Formula (14.7) we can get the optimal steady water consumption and optimal water quality of the whole society, namely

$$w_i^* = w_i^*(P, S, E, \lambda_1, \lambda_2, h, m) \tag{14.8}$$

Next, we will compare the optimal decision of the whole society and individual farmer's decision. If water resources are free, farmers will not bear any economic responsibility for the water they use and water pollution. If farmers make decisions independently, and there is no cooperation between them (namely, there is no need to consider the interest of others), under the premise of aforementioned conditions, farmers maximize their own profits by using the water, thus

$$\max_{w_i} Pf(w_i, E) - c(S)w_i \tag{14.9}$$

Formula (14.9) indicates that, unlike planners that pursue social optimization, individual farmer doesn't consider constraint Formulas (14.2) and (14.3) when making decisions, i.e. he will ignore the impact of his decisions on underground water level and pollution. Therefore, for individual farmer, Formula (14.9) has a condition for maximization

$$Pf_w(w_i, E) - c(S) = 0 \tag{14.10}$$

Formula (14.10) provides an optimal solution for individual farmer when the water consumption of the whole society and water quality are stable. By comparing Formulas (14.10) and (14.7), the optimal tax rate (which can eliminate the difference between the above two formulas) is

$$T(t) = h\lambda_1^*(t) + (1 - h)m\lambda_2^*(t) \tag{14.11}$$

In the optimal tax rate, the first part tries to eliminate the externalities of water consumption, i.e. rising extraction cost, land salinization and sea water intrusion resulting from excess extraction. The second part tries to eliminate the externalities of water quality, i.e. water pollution. As there is no inevitable connection between water consumption and water quality, in reality water resource tax and water pollution tax are often independently levied.

14.3 Conditions for Reducing Agricultural Diffused Pollution Through Water Conservation in Taihu Lake Region

According to the conditions of China, we believe that the approach to reduce water pollution through water conservation in above-mentioned optimal model of water for agricultural use and the assumption to levy water pollution tax according to the consumption of agricultural water provides an effective solution to the problem of eutrophication caused by the influx of agricultural fertilizers into natural water bodies.

Agricultural diffused pollution is an important reason for the eutrophication of natural water bodies. The monitoring of Dapu Town, Yixing of Jiangsu Province, which is on the west of Taihu Lake by the Institute of Soil Science of Chinese Academy of Sciences in 2003–2006 shows that nitrogen pollutants and phosphorus pollutants from farmland fertilizers respectively accounted for 39 % and 20 % of the total annual nitrogen and phosphorus pollution of the town.[1]

Nitrogen, phosphor and other substances that lead to the eutrophication of natural water bodies are effective constituents of fertilizers. Currently, the overuse of chemical fertilizers in agriculture is very serious. According to statistics, the average use of chemical fertilizers per hectare of farmland in Taihu Lake Watershed (pure quantity) rose from 24.4 kg in 1979 to the current 66.7 kg. But in some developed countries, it is stipulated that the use of chemical fertilizers should not exceed 22.5 kg per hectare of farmland each year.[2]

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[1] Jiangsu: Diffused Pollution Aggravates, China Environment Daily, July 19, 2007.

[2] Challenges for 36 Million People: **Treatment of Domestic Sewage,** twenty-first Century Business Herald, July 26, 2007.

Although the eutrophication of natural water bodies is caused by chemical fertilizers, a pollution tax shouldn't be levied upon chemical fertilizers. Nitrogen and phosphor in fertilizers don't cause pollution in farmland. Only when carried by agricultural water into natural water bodies through surface runoff and leakage will they cause eutrophication. Agricultural water comes from precipitation and irrigation. Precipitation is beyond people's control (or the control cost is too high), but irrigation can be controlled. If the irrigation efficiency coefficient h is increased, the amount of irrigation water can be reduced by w_i while the amount of water efficiently used by crops hw_i remains unchanged. The increase in h and decrease in w_i will both effectively reduce the loss of water $(1\text{-}h)w_i$, which in turn effectively reduce the pollutant increase (nitrogen and phosphor) $(1\text{-}h)mw_i$ caused by the loss, thus curbing the eutrophication of natural water bodies from the source. The decrease in nitrogen and phosphor loss means the increase in chemical fertilizer utilization efficiency. Without affecting the growth of crops, the decrease in nitrogen and phosphor loss will reduce the use of chemical fertilizers.

Next, we will use Taihu Lake Watershed as an example to discuss conditions for reducing agricultural diffused pollution through water conservation.

Currently, there is a severe water crisis in Taihu Lake Region. From the perspective of water pollution, eutrophication of Taihu Lake is very serious. In late May of 2007, due to the outbreak of blue algae in Taihu Lake, the quality of tap water in Wuxi of Jiangsu Province on the northwest of the lake severely deteriorated and the water became undrinkable. Therefore, local residents had to buy bottled mineral water and purified water. This water crisis made a sensation throughout China. From the perspective of water resources, water pollution causes the use function of water bodies to decline or even lose. As a result, Taihu Lake region which is abundant with water resources underwent a quality-induced water shortage (Wu Chucai et al. 2004). The reduction of agricultural diffused pollution through water conservation will help prevent the eutrophication of natural water bodies and alleviate the quality-induced water shortage, thus contributing to social and economic progress in Taihu Lake region.

To reduce agricultural diffused pollution, we need to, on the one hand minimize the amount of irrigation water w_i, and on the other hand, increase the irrigation efficiency coefficient h. Technically, we think that the following three tasks should be fulfilled.

First, the meteorological department needs to provide precipitation forecasts on a weekly/semi-monthly basis so that natural precipitation can be made full use of in agricultural production.

Second, precision irrigation should be carried out. The water supply should be decided according to the crop growth conditions in different farmland lots. The farmland irrigation conditions in Taihu Lake region are very good. Thanks to the financial support from collectively-owned rural enterprises (which were rejuvenated in the 1970s), agricultural production conditions were significantly improved in Taihu Lake region through land leveling, lot assemblage and construction of water conservancy projects. As a result, many farmland lots of similar size which can be independently irrigated and drained emerged. Also, thanks to the financial support from rural enterprises and local governments, these farmland lots, to a great extent, still exist today. Therefore, it is possible to carry out lot-specific irrigation in Taihu Lake region.

Third, leakage in irrigation should be minimized.

From the perspective of economic motivation mechanisms, the previous irrigation charging system in Taihu Lake region had several drawbacks. First, the price of water for agricultural use was too low, and water conservation couldn't bring much economic benefit. Second, the water charge was collected according to the acreage of crops. As long as the same crops (such as single cropping rice) were grown, the charge would be the same regardless of the amount of water that was actually used.

To conserve water, it is suggested that the charge of water for agricultural use should be dramatically increased in Taihu Lake region. In order not to increase the production costs of related agricultural products and not to lower the income of farmers, the government should provide subsidies for farmers (not necessarily the land contractors). The amount of the subsidies should equal the result of the new water charge rate minus the previous water charge rate and then multiplied by the reasonable amount of irrigation water. The increased water charge resulting from the charge rate increase should be turned over to the treasury as special revenues and used to (partially) offset the financial burden caused by the subsidies.

Precision irrigation will dramatically increase the workload of water consumption measurement and the difficulty in monitoring. Therefore, it should be carried out according to actual abilities. At first, the water consumption can be measured for each sub-lateral canal (the water conservancy conditions in Taihu Lake region are very good, and all lateral canals and sub-lateral canals are equipped with sluice gates) and lateral canal, and then for each farmland lot when possible.

14.4 Conclusion

Water conservation in agriculture can reduce the amount of water for agricultural use flowing into natural water bodies, and fundamentally mitigate the eutrophication of natural water bodies resulting from the influx of chemical fertilizers into natural water bodies with water. Therefore, it is worth trying on a pilot basis.

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Chapter 15
Verification of EKC Relation Between Economic Growth and Agricultural Diffused Pollution: An Analysis Based on Inter-Provincial Panel Data

Liang Liutao

15.1 Emergence of Problems

Currently, water environment pollution has become an important factor that affects socio-economic sustainability. From the types of pollution sources, water pollution can be divided into point-source and diffused (non-point-source) pollution. According to a lot of studies, diffused pollution is the primary cause of deteriorating water environment quality, in which agricultural diffused pollution accounts for a considerate proportion. For instance, in the Netherlands, nitrogen and phosphor from farmland account for 60 % and 50 % of the total, respectively. In the U.S., over 60 % surface water environment problems are caused by agricultural activities. Agricultural diffused pollution also contributes to 63.6 % of the eutrophication in rivers and lakes in China. In this context, how to control agricultural diffused pollution is a top priority and difficult tasks. According to relevant studies, economic development is an important factor affecting agricultural diffused pollution. Therefore, to dive into the relation between economic growth and agricultural diffused pollution, and explore how the agricultural diffused pollution will evolve with economic growth will play an important role in addressing agricultural diffused pollution.

The relation between environmental pollution and economic growth remains one of the most important issues in resource-environmental economics. The U.S. economists Gene Grossman and Alan B. Krueger (1992) proposed the EKC (Environmental Kuznets Curve) hypothesis, assuming that in the process of economic growth, the environmental quality will undergo a process of deterioration before improvement. This hypothesis is widely recognized and used in the study of the relation between resource-environment and economic development. For

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instance, Chinese and foreign scholars use typical national or regional cross-section data, time sequence or panel data for research on whether the EKC exists. How does the agricultural diffused pollution, as an important source of environmental pollution, evolve in the process of economic growth? Does it conform to the EKC hypothesis? Some foreign scholars have started to study this issue. For instance, Shunsuke Managi (2006) proved that the pollution caused by pesticides conforms to the EKC hypothesis, and Yoshiaki Tsuzuki (2007) used empirical data to prove that there is an inverted U-shaped relation between pollutants flowing into water and per capita GDP in the process of land utilization [18]. Chinese scholar Xu Xiaowen (2007) also realized the inverted U-shaped relation between economic growth and agricultural diffused pollution. However, she only conducted theoretical analysis but didn't carry out empirical analysis. For this reason, we will use inter-provincial cross-section data to analyze the relation between agricultural diffused pollution and economic growth and verify whether the EKC exists in agricultural production in China so as to provide reference for formulating agricultural environmental policies and controlling economic development quality.

15.2 Research Methods and Models

15.2.1 Measurement of Agricultural Diffused Pollution: Element-Based Comprehensive Survey and Assessment

Currently, the quantitative analysis of agricultural diffused pollution mainly leverages a lot of watershed-based simulation to establish the response relation between agricultural activities and water environmental quality. But due to the absence of characteristics of diffused pollution, water quality monitoring, agricultural activities and survey data, this traditional method isn't applicable to large-scale regional agricultural environmental pollution assessment, because it is both difficult and impractical to measure the agricultural environmental pollution by simulating and totaling the impact of agricultural activities on water environment in many watersheds in a large scale. In this context, the quantitative analysis method based on comprehensive surveys gradually arouses attention and becomes an important technical method for quantitative study of diffused pollution. In recent years, Chinese scholars have conducted a series of special studies on diffused pollution in key watersheds and some small watersheds or regions in China, and achieved many study results. Lai Siyun et al. (2004), Chen Minpeng, Chen Jining et al. (2006) extended this method and created an element-based comprehensive survey and assessment method. The core concept of this method is to, starting from agricultural activities, based on agricultural statistics, assume that certain agricultural activities correspond to certain agricultural pollution discharge, and apply multiple analysis methods to establish the response relation between agricultural activities and pollution discharge. The biggest advantage of this method is that it is applicable to the large-scale measurement of regional agricultural diffused pollution load. In this paper, we will use this method to calculate the total discharge of agricultural diffused pollution in different provinces between 1997 and 2005.

The COD, TN and TP pollution generated in agricultural production will be analyzed according to the degree of damage caused by water environment pollution. The detailed process to assess the agricultural diffused pollution is as follows: first, the pollution will be broken into different element unit (EU) which refer to independent elements generating pollutants and contribute to diffused pollution. Agricultural diffused pollution comes from chemical fertilizers in farmland, livestock, poultry, solid waste and gas from farmland and domestic sewage in rural areas (Zhang Weili et al. 2004), which are broken into the basic elements of agricultural diffused pollution (See Table 15.1); second, based on documentary research, relations between pollution elements, amount of pollution generated and pollution discharge are established.

The formulas to calculate the amount and intensity of pollutants are as follows:

$$E = \sum_i EU_i \rho_i (1 - \eta_i) C_i (EU_i, S) = \sum_i PE_i (1 - \eta_i) C_i (EU_i, S) \tag{15.1}$$

$$EI = \frac{E}{AL} \tag{15.2}$$

In which E represents the amount of pollutants discharged in agriculture and rural areas, EU_i is the indicator statistics of element i, ρ_i stands for the pollutant producing intensity coefficient of element i, η_i is the coefficient of related resource utilization rate, PE_i represents the amount of pollution in agriculture and rural areas (maximum potential amount of pollutants from agricultural production and rural life regardless of the comprehensive utilization of resources and management), C_i is the discharge coefficient of pollutant J of element i, which is decided by element and space characteristics and represents the overall impact of regional environment, precipitation, hydrology and various management measures on pollution in agriculture and rural areas. *EI* is the intensity of agricultural diffused pollution, which characterizes the enrichment degree of pollution in agriculture and rural areas and

Table 15.1 Elements of agricultural diffused pollution

Pollution source	Element	Indicator	Unit
Chemical fertilizers	Nitrogen and phosphor	Application amount (pure quantity)	10,000 t
Livestock and poultry	Cows, horses, donkeys, mules, pigs, sheep/goats and poultry	Stock/slaughter	10,000 heads
Solid waste and gas	Rice, wheat, corn and beans	Total output	10,000 t
Rural domestic sewage	Rural population	Agricultural population	10,000

the impact on the environment. *AL* is the size of farmland in the survey region, mainly including cultivated land, garden plots and grass plots.

15.2.2 EKC Panel Data Model

In traditional EKC study, there are three types of data that are used, i.e. time series data, cross-section data and panel data. As time series data and cross-section data are more difficult to collect and longer in length, the model estimation is often unstable. The panel data can increase the sample size by combining time series data and cross-section data and increase the credibility of model estimation. Also, the environment-income EKC shape has not only time series characteristics, but also cross-section characteristics. That is to say, the environment-income relation of a country or region will change along with economic development. Also, inverted U-shaped differences exist in the environment-income relation between countries or regions on different development levels. In this paper, inter-provincial panel data is used to verify and analyze the relation between agricultural diffused pollution and economic growth.

To verify the EKC hypothesis, the environmental quality indicator is often used as a dependent variable and the per capita income is used as an independent variable to fit the equation. To use data in China to verify the agricultural EKC, COD, TN, TP and other environmental pollution indicators are used as dependent variables, and per capita GDP as an independent variable to fit the equation. Moreover, results of other studies are combined and the following EKC panel data model is applied.

$$E_{it} = \alpha_i + \beta_{1i} AGDP_{it} + \beta_{2\mathrm{i}} AGDP_{it}^2 + \sigma \tag{15.3}$$

E_{it} represents the environmental pollution indicator of province i in year t, $AGDP_{it}$ the per capita GDP of province i in year t, α_i the specific cross-section effect, β_1 and β_2 the model coefficients and σ the random error term. According to regression result of Formula (15.3), the following possible coefficients can be drawn for the environment-per capita income model:

1. When $\beta 1 \neq 0$ and $\beta 2 = 0$, there is a linear relation between the environment and per capita income;
2. When $\beta 1 > 0$ and $\beta 2 < 0$, the relation between the environment and per capita income conforms to inverted U-shaped EKC;
3. When $\beta 1 < 0$ and $\beta 2 > 0$, There is a U-shaped curve between the environment and per capita income.

If it conforms to the EKC inverted U-shaped curve, the corresponding turning point can be calculated according to Formula (15.4).

$$AGDP^* = -\beta_1/2\beta_2 \tag{15.4}$$

As the panel data has both the cross-section and time series characteristics, the model assumption directly decides the validity of model estimation. Therefore, first a hypothesis testing must be done for the assumed model to verify whether it has the same parameters on all cross-section and time series sample points. The panel data mainly falls into hybrid model, variable-intercept model and variable-coefficient model. The variable-intercept model can be divided into fixed effect (FE) model and random effect (RE) model. As the variable-coefficient model is seldom used (Greene 1994), in this paper we will mainly consider the hybrid model and variable-intercept model for the estimation of panel data, and decide whether the hybrid model or variable-intercept model should be used according to the result of F-test. Also, we will choose between the fixed effect model and the random effect model according to the result of the Hausman test, and determine whether the hybrid model and variable-intercept model should be used according to the result of F-test.

15.3 Measurement and Calculation of Total Aagricultural Diffused Pollution

15.3.1 Data Collection

An element-based survey method is used to assess the agricultural diffused pollution of all provinces in China. The pollutant producing coefficient, resource utilization coefficient and loss coefficient in Formula (15.1) are determined according to the research on agricultural diffused pollution in representative regions. Based on the related sub-regional experiments conducted by various organizations, a database is established for the element-specific coefficients of different regions. Moreover, as the pollutant producing coefficient, resource utilization coefficient and loss coefficient are heavily influenced by regional factors, including precipitation, soil and agricultural production characteristics, and vary significantly from region to region in China, a region-specific value assignment will be conducted according to the water resources and soil types. Values of coefficients of all regions are the averages of document surveys.

Data on fertilizer application, output of crops, size of farmland, number of livestock and poultry and rural population used in the calculation is mainly quoted from the *China Statistical Yearbook* and *China Rural Statistical Yearbook* in 1998–2006.

15.3.2 Calculation of Total Emissions and Intensify of Agricultural Diffused Pollution

The total emissions and intensity of COD, TN and TP of agricultural diffused pollution of all provinces in 1997–2005 are calculated according to formulas (15.1) and (15.2), and then summarized to get the total emissions and average intensity of agricultural diffused pollution of China during the period (See Tables 15.2 and 15.3). The average agricultural non-point source COD, TN and TP emissions of China in 1997–2005 were respectively 7.485 million tons, 5.829 million tons and 0.593 million tons. They were slightly different from the estimations of Chen Pengmin et al. (2006). This indicates that the result of agricultural diffused pollution estimated with this method is quite reliable. The average agricultural non-point source COD, TN and TP emissions intensity was respectively 21.34, 17.18 and 1.69 kg/hm^2.

The emissions and intensity of agricultural diffused pollution varied significantly from region to region in 1997–2005 (See Fig. 15.1). Provinces with higher agricultural diffused pollution emissions mostly have large populations and

Table 15.2 Total emissions of agricultural diffused pollution in China in 1997–2004

Year	COD	TN	TP
1997	684.9	546.8	55.8
1998	736.3	572.2	57.2
1999	721.9	570.7	57.8
2000	737.7	573.4	58.4
2001	741.0	573.9	58.9
2002	750.9	578.1	59.6
2003	767.2	585.1	60.5
2004	782.7	633.0	61.9
2005	813.6	613.1	63.8
Average	748.5	582.9	59.3

Unit: 10,000 t

Table 15.3 EKC regression results of agricultural diffused pollution

	COD model	TN model	TP model
Model method	FE	RE	FE
α	6.480205***	4.890615***	0.637384***
β_1	0.001676***	0.001376***	0.000122***
β_2	−1.31E-08*	−1.03E-08**	−1.13E-09**
R	0.447792	0.492361	0.435548
F value	6.233873***	7.456126***	5.931910***
D-W	1.792682	1.824954	1.711590
Turning point	63969.47	66796.12	45035.46

Note: ***, ** and * respectively passing the Significance Level test respectively at 1 %, 5 % and 10 %

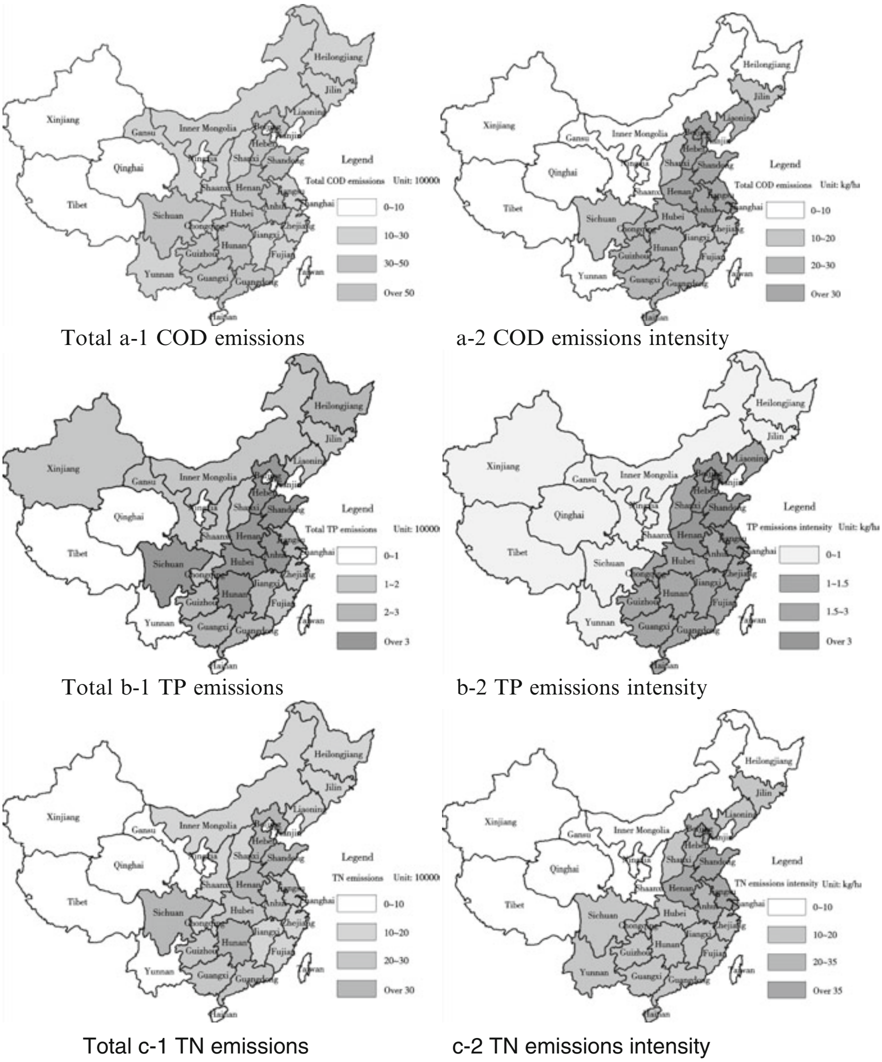

Fig. 15.1 Total agricultural diffused COD, TN and TP emissions and intensity of China

intensive agriculture, such as Shandong, Henan, Hebei, Sichuan, Jiangsu, Hubei and Anhui. Provinces with higher emissions intensity are mostly highly populated, such as Shandong, Jiangsu, Henan and Tianjin.

15.4 Empirical Study of EKC for Agricultural Diffused Pollution

We will use the panel data of 31 provinces in 1997–2005, and COD, TN and TP emissions intensity, per capita GDP and the square of per capita GDP to do regression analysis according to Formula (15.3) to verify whether the EKC hypothesis of agricultural diffused pollution exists.

15.4.1 Verification of EKC Hypothesis for Agricultural Diffused Pollution

When doing regression analysis of the panel data, we should first choose between the hybrid model and variable-intercept model. If the variable-intercept model is chosen, we should compare the RE model with the FE model. In view of the impact of cross-section heteroscedasticity of samples of different regions on the estimation validity, both the hybrid model and the FE model should adopt cross-section weights to eliminate cross-section heteroscedasticity. The RE model should adopt the GLS estimation method based on RE transformation equation. Moreover, in actual estimation, we can determine whether the regression residual has a serial autocorrelation problem according to the DW statistics of estimation result, and add AR to the estimation equation to eliminate serial autocorrelation, if any. See Table 15.3 for detailed regress results.

15.4.1.1 EKC Hypothesis Test of COD Emissions Intensity

We should, according to the F-test and Hausman test results, choose the FE model whose regression equation coefficient passes the test at 1 % of 10 % confidence level and overall goodness of fit is good. According to the regression results, the evolution of COD emissions intensity with per capita income presents an inverted U-shaped relationship, which conforms to the EKC hypothesis. With Formula (15.4), we can calculate that the turning point is at the critical GDP value of RMB 63,969.47. The economic significance of this estimation result is obvious. From regional development, we can see that when per capita GDP exceeds the critical value of RMB 63,969.47, the regional COD emissions intensity is negatively correlated with the per capita GDP. That is to say, as the per capita GDP grows, the COD emissions intensity will decline. However, in regions where the per capita GDP is below the critical value, the COD emissions intensity will rise as the per capita GDP increases. By comparing the actual per capita GDP of all regions and the critical value of RMB 64,337 in 2005, we can see that even Shanghai which was the most economically developed region (per capita GDP 51,747) failed to reach the turning point. So the local COD emissions intensity and the economic growth were both rising. This indicates that China's economic growth process will still be accompanied by an increase in agricultural diffused COD emissions intensity.

15.4.1.2 EKC Hypothesis Test of TN Emissions Intensity

We should, according to the F-test and Hausman test results, choose the RE model whose regression equation coefficient passes the test at 1 % of 5 % confidence level and overall goodness of fit is good. According to the regression results, there is an inverted U-shaped relationship between per capita income and TN emissions intensity, which conforms to the EKC hypothesis. With Formula (15.4), we can calculate that the turning point is at the critical GDP value of RMB 66,796.12 in 2005. No province reached the turning point in term of critical point in 2005, with a large gap to cover. This indicates that China's economic growth process will still be accompanied by an increase in agricultural diffused TN emissions intensity.

15.4.1.3 EKC Hypothesis Test of TP Emissions Intensity

We should, according to the F-test and Hausman test results, choose the FE model whose regression equation coefficient passes the test at 1 % of 5 % confidence level and overall goodness of fit is good. According to the regression results, there is an inverted U-shaped relationship between per capita income and TP emissions intensity, which conforms to the EKC hypothesis. With Formula (15.4), we can calculate that the turning point is at the critical GDP value of RMB 45,035.46 in 2005. Except for Beijing and Shanghai (where the per capita GDP stood at RMB 51,747 and 45,444 respectively), no province reached the turning point in term of critical point in 2005, with a large gap to cover (the per capita GDP of Tianjin which ranked the 3rd stood at RMB 35,783). This indicates that the TP emissions intensity will increase with economic growth in most provinces, and the overall situation of the province still resided in the left of EKC.

15.4.2 Analysis of the Empirical Test Result

In conclusion, the evolution trends of COD, TN and TP – the three major agricultural diffused pollutants in China conform to the EKC. This shows that the EKC theory also applies to agricultural production in China. The EKC shows obvious regional disparities, i.e. the economically less developed western regions reside in the left bottom of the EKC, while the more developed regions, including Beijing and Shanghai, are at the turning point, which have shown or are showing inflection points. According to the real conditions of agricultural production, this conclusion is credible. In the economically less developed western regions, the population density is low, agricultural production is still quite extensive, and the input of chemical fertilizers and pesticides is low. Therefore, the pollution caused by farming is quite insignificant. Although the pollutants caused by animal husbandry account for a large proportion, due to the large area, the emissions intensity per unit area is very low. In the more developed central and some eastern regions, the emissions intensity of agricultural diffused pollutants is quite high. This is mainly because the agricultural population is large and dense, and also these regions are major agricultural production bases where agricultural production is quite intensive. Driven by economic benefits, chemical fertilizers, pesticides, agricultural films and other materials that damage the environment are widely used by farmers. Also, due to the low technological level of economy, the pollution producing coefficient of agriculture is quite high. In Shanghai, Beijing and economically developed regions, people's consumption of agricultural products has shifted from quantity to quality and clean agricultural production has started to produce effects to play an important role in controlling pollution. Moreover, the economic strength accumulated by the government through development has been directed to environmental improvement and land management. As a result, the momentum of exacerbating agricultural diffused pollution has been contained and started to grow better.

The turning points of inverted U-shaped curves between agricultural diffused COD, TN and TP pollution and economic growth are respectively RMB 63,969.47, 66,796.12 and 45,035.46. In 2005, the per capita GDP of China was RMB 14,040, with a large gap to cover to reach the turning points. Therefore, according to the ECK theory, if the management and control of pollution sources are not intensified, the agricultural diffused pollution emissions intensity will continue to increase and China will move up on the EKC for a long time to come. From the agricultural development trend in China's economic growth process, this conclusion is credible. First, the output and consumption of chemical fertilizers and other agricultural materials are still on the rise. The application of chemical fertilizers rose from 25.90 million tons in 1990 to 47.66 million tons in 2005. The total consumption reached a quarter of the world's total and the consumption intensity 1.6 times of the world's average (Institute of Agricultural Economy and Information under Jiangsu Academy of Agricultural Sciences et al. 2006). As clean agricultural production can't be propagated quickly, the trend of rising chemical fertilizer consumption can't be reversed within a short time, and the pollution caused by chemical fertilizers will continue to rise. Second, the agricultural restructuring will result in intensified agricultural diffused pollution. According to farming restructuring, the production of vegetables, fruits and flowers are likely to become China's most competitive agricultural sector in the international market. In recent 10 years, the acreage of vegetables, fruits and flowers has grown about three times, and the growing area is now over 3×10^7 hectare all-round the year. The production of vegetables, fruits and flowers is now quite intensive, posing a large demand of chemical fertilizers and other polluting agricultural materials. Also, it is a new sector which lacks related technological reserves and technical standards suitable for local farmers. Therefore, the overuse of chemical fertilizers is quite popular, which causes severe environmental pollution. It is predicted that the acreage of vegetables, fruits and flowers will continue to grow in the next few years (Zhang Weili et al. 2004). Therefore, the potential threat of water eutrophication caused by the production of vegetables, fruits and flowers will continue to grow. According to the agricultural structure, the livestock and poultry breeding has developed rapidly in recent years. The pig stock of 2005 was 1.5 times of 1990. The increase in livestock population directly results in the output of livestock and poultry manure, which is now 4 times industrial solid waste. From the land load of livestock and poultry manure, China's overall land load alert value is now somewhat threatening to the environment, and some regions even report severe or close to severe environmental pressure (Cui Jian 2006). With further socio-economic development, the demand of livestock and poultry products will rise accordingly. In the future, China's livestock and poultry breeding will maintain a rapid growth. Moreover, problems like low treatment rate of sewage generated by livestock and poultry and low manure utilization rate won't be fundamentally solved within a short time. So, the pressure brought by livestock and poultry breeding to the environment will further increase. In summary, the agricultural diffused pollution will continue to grow with economic development.

15.5 Conclusions and Policy Implications

In this paper, an element-based comprehensive survey and assessment method is used to assess the agricultural diffused COD, TN and TP emissions and intensity in 1997–2005, and analyze the evolution of relation between economic growth and agricultural diffused pollution under the framework of EKC hypothesis. On top of that, the following conclusions are drawn.

1. The evolution of COD, TN and TP – the three major agricultural diffused pollutants in China, conforms to the EKC hypothesis. That is to say, the emissions intensity of agricultural diffused pollution first rises and then declines as the economy grows.
2. The turning points of the inverted U-shaped relation between economic development and agricultural diffused COD, TN and TP pollution are respectively RMB 63,969.47, 66,796.12 and 45,035.46. The per capita GDP of most provinces is below the EKC turning point, and there is a large gap to cover in most of them. From the current economic development, the agricultural diffused pollution will reside in the left of the EKC for a long time. Moreover, the pressure of agricultural diffused pollution to economic growth will continue to increase. So the environmental situation is not cheerful.
3. From the disparities of regional economic development, regions at different economic development levels are at the different stages of the EKC. The less developed western regions are at the bottom of the EKC, the more developed central and some eastern regions are at the left middle, and developed regions

including Beijing and Shanghai are at the turning points and have reached or are reaching inflection points. Therefore, to manage agricultural diffused pollution, measures should be taken according to local conditions for regions at different EKC stages. In less developed regions, we should give full play to the second-mover advantages, improve agricultural infrastructure, introduce advanced agricultural technologies and experience, enhance farmers' environmental awareness and prevent the agricultural ecological environment from deteriorating. In central and some eastern regions, we should control the agricultural diffused pollution by optimizing the agricultural structure and developing environment-friendly agricultural production patterns. In Beijing and Shanghai which are at the turning point, clean agricultural production has begun to take shape and played an extremely important role in reducing agricultural diffused pollution. Therefore, it should be further propagated.

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Chapter 16
Measurement of Environmental Justice Under Regional Disparities and Study of Countermeasures – with Jiangsu Province as Example

Zhao Haixia and Wang Bo

Since the kickoff of reform and opening up, with the rapid social and economic development, China's environmental problems get increasingly serious. A review of the emergence and development of environmental problems will reveal that not all social strata cause the same degree of environmental damage, and people with different social backgrounds and lifestyles will have different impacts on the environment. Moreover, environmental risks are not evenly distributed among all social members. Different social strata and regions are subject to different proportion of environmental risks. This concerns environmental justice. Particularly, as the inter-regional economic disparities widen, the issue of environmental justice among all regions gets more and more obvious. This poses a threat to the distribution of limited environmental capacity among regions, and a potential hazard to coordinated and sustainable development among regions.

Adherence to the scientific outlook of development to ensure environmental justice and coordinated development among regions has now become an important research subject on building a harmonious socialist society. In this paper, we will, taking Jiangsu Province as an example and based on the analysis of regional differences and development trends, build an environmental justice assessment index system to assess the environmental justice under regional differences and put forth suggestions on regional coordinated development.

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16.1 Theoretical Basis of Environmental Justice

16.1.1 Concept Definition

After it was created in the U.S., the concept of environmental justice soon spread around the world. Its content can be summarized as follows: first, it implies the justice in distributing environmental benefits among all living people; second, it advocates intergenerational justice, particularly justice between people of the present and future generations; last but not least, it introduces the idea of inter-species justice, i.e. justice between men and other biological species.[1] Some Chinese scholars, from an economic perspective, think that environmental justice is the right for everyone to live in an environment where their health and other welfare factors are not harmed, and no individual or group shall be forced to take the consequence of environmental pollution in disproportion with the consequences of their actions. Other scholars, from the perspective of building environmental ethics, propose to establish regulations on environmental justice, i.e. regulations emphasizing the equity on opportunity for environmental resources and benefits, including regulations on two aspects, namely intra-generational and inter-generational equity on environmental benefits. From the legal perspective, it means that all subjects are equal in term of using and protecting environmental resources, have the same rights, shoulder the same responsibilities, and are liable to prevent environmental damages and improve the environment when they are engaged in activities that affect the environment. Unless otherwise stipulated by laws, no subject should be forcefully subject to any environmental charges or burden. The environmental rights of all subjects should be reliably guaranteed, and remedied in an effective and timely manner when harmed. Moreover, any behavior by subjects that violates the environmental responsibilities should be corrected and punished in an effective and timely manner.

In reference to the definition, environmental justice in this paper refers to the effort to "take inter-generational justice and regional sustainability into full consideration, guarantee that the total net environmental benefits are positive and not declining and ensure inter-regional equalization of environmental costs or environmental risks of socio-economic output so as to promote coordinated economic and environmental development and enable people living in different regions to enjoy roughly equal net environmental benefits".

[1] United Church of Christ (UCC), Commission for Racial Justice, 1987, Toxic Wastes and Race: A National Report On the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites, New York: United Church of Christ.

16.1.2 Related Research

In response to people's attention to environmental justice, the U.S. government adjusted relevant policies. Research on environmental justice emerged therefrom, which is focused on the susceptibility of new population, disadvantaged groups and low social strata to environmental risks when facing environmental pollution. Research by Chinese scholars on environmental justice is focused on the qualitative description of concepts, basic theories and representations. In addition, Zhang Changyuan (1999) proposed that inter-generational environmental justice is the prerequisite for sustainability. Ye Minqiang (2002) argued that due to the fact that developed regions transfer pollution industries and pollutants to less developed regions in context of industrial restructuring and increasingly stringent environmental control, people begin to shift their attention to regional environmental justice. Therefore, the projection of environmental issues on different reality backgrounds gives rise to different issues of environmental justice, including environmental justice between different social strata, environmental justice between the present and future generations and environmental justice between regions at different economic development levels.

16.2 Regional Disparities in Jiangsu

16.2.1 Economic Development Levels Demonstrate Significant Regional Disparities

Economic development levels are often measured with economic output scales, such as GNP, GDP or per capita GDP. On the whole, the economic aggregate of Southern Jiangsu has long taken up half of the province. In 1998, the GDP of Southern Jiangsu accounted for 57 % of the whole province, and this proportion exceeded 62 % in 2005. The proportion of Central Jiangsu remains relatively stable, while that of Northern Jiangsu is on the decline. This shows that the economic disparities between the three regions, especially Southern and Northern Jiangsu are widening. In term of per capita GDP, changes in the disparities between the three regions are particularly obvious. In 1998, the per capita GDP of Southern Jiangsu was about 2.4–3.5 times of Central and Northern Jiangsu. This ratio increased to 2.7–4.5 times in 2005. By calculating the per capita GDP gradient, standard deviation and coefficient of variation (Table 16.1) of Southern, Central and Northern Jiangsu, we can see that the economic disparities between the three regions are widening. Compared with 1998, the standard deviation of per capita GDP of Southern, Central and Northern Jiangsu was increased two times and the coefficient of relative deviation increased by 18 % in 2005. This shows that both the standard deviation and relative deviation in regional economic development of Jiangsu Province has been rising year on year since 1998.

Table 16.1 Disparities of per capita GDP of Southern, Central and Northern Jiangsu

Year	Gradient	Standard deviation	Coefficient of variation
1998	13,339	7092	0.664
1999	16,655	8530	0.651
2000	16,009	8508	0.674
2001	18,080	9634	0.688
2002	20,951	11,205	0.708
2003	26,798	14,373	0.761
2004	32,961	17,620	0.770
2005	39,360	20,910	0.782

Note: The table is derived from the current year prices, and the data is obtained from the *Statistical Yearbook of Jiangsu Province* in 1999–2006

16.2.2 Regional Disparities of Environmental Pollution Are Widening

From the perspective of overall environmental pollution, the discharge of industrial waste water and emissions of waste gas of Southern Jiangsu have taken up over a half of the total for a long time. Table 16.2 lists the proportions of environmental pollutants of Southern, Central and Northern Jiangsu in 1986 and 2005. It shows that the regional disparities of environmental pollution are widening. Also, by calculating the coefficient of variation of in pollution in Southern, Central and Northern Jiangsu, we can judge that the disparities of total pollution of the three regions are widening. Particularly, the disparities of industrial waste gas rose rapidly from 0.68 in 1991 to 0.92 in 2005. The disparities of industrial waste water fluctuated dramatically in 1990–1994. After that, it rose rapidly from 0.8 in 1994 to 1.1 in 2005. From the perspective of elasticity coefficient of economic pollution,[2] except for per capita waste water intensity, the coefficients of all four indexes have been larger than 1 since 1990, and rising rapidly since 1995. This shows that regional disparities of environmental pollution increase progressively as the economic disparities widen at a rate much higher than the latter. That is to say, changes in the pollution proportions of developed and less developed regions show the same trend as changes in the GDP proportions. Under traditional economic growth patterns and before reaching certain development stages, primary industrial pollution is positively correlated with economic development and industrialization. Before this pollution is effectively controlled, regional disparities of environmental pollution will continue to widen.

[2] Derived by dividing the pollution growth rate of Southern Jiangsu relative to Northern Jiangsu by the economic growth rate of Southern Jiangsu in relative to Northern Jiangsu.

Table 16.2 Region-specific pollution proportions

		Waste water	Waste gas	Solid waste
1986	Southern	65.7	59.8	46.3
	Central	13.8	12.9	10.5
	Northern	20.5	27.3	43.2
2005	Southern	74.2	68.5	67.7
	Central	14.3	10.8	9.7
	Northern	11.5	20.7	22.6

Unit: %
Note: obtained from the *Statistical Yearbook of Jiangsu Province* in 1987 and 2006

16.2.3 Economic Development and Regional Disparities of Environmental Pollution Grow Simultaneously

As the economy grows at a faster pace, the regional disparities of environmental pollution also grow more quickly. This can be seen from Table 16.3, in which all values are the ratios between Southern and Northern Jiangsu. The economic development level of Southern Jiangsu (in per capita GDP) was 2.46 times of Northern Jiangsu in 1986. This ratio was on the rise year by year and reached 4.16 times in 2003. However, the regional disparities of environmental pollution are even more unoptimistic. The ratios of per capita and region-specific waste water intensity, per capita and region-specific waste gas intensity respectively rose to 3.64, 2.8, 3.02 and 2.6 times, showing a simultaneous growth with the regional disparities of economic development. But the regional disparities of economic development are far below the regional disparities of environmental pollution.

16.3 Assessment of Environmental Justice in Jiangsu Province

16.3.1 Assessment of Environmental Justice Indicators

When it comes to justice, it is generally believed that justice is more correlated with social ethics. The definition, measurement and survey of justice are the prerequisites for scientific explorations of this issue. In 1965, J. Stacy Adams from the U.S. proposed the classic equation of justice as follows:

$$O_p/I_p = O_o/I_o \tag{16.1}$$

in which O_P is the person's perception of the outcomes received, I_p is the person's perception of personal inputs, O_o is the person's perception of the outcomes that a comparison person (or comparison other) received, and I_o is the person's perception of the inputs of the comparison person (or comparison other). This formula suggests

Table 16.3 Ratios of economic development and environmental pollution indexes between Southern and Northern Jiangsu

	Ratio of per capita GDP	Ratio of per capita waste water intensity	Ratio of region-specific waste water intensity	Ratio of per capita waste gas intensity	Ratio of region-specific waste gas intensity
1986	2.46	3.18	5.99	2.18	4.10
1990	2.65	4.99	6.61	3.58	4.75
1995	3.54	4.27	5.59	3.40	4.45
2000	3.55	6.57	8.43	3.82	4.89
2003	4.16	6.82	8.79	5.20	6.70

Note: Related data is obtained from the *Statistical Yearbook of Jiangsu Province* and the *Environmental Statistical Bulletin of Jiangsu Province*

that participants believe that equity exists when they perceive the ratio of inputs to outcomes received is equivalent to that of some comparison other or referent.[3] Therefore, justice is a psychological evaluation arising from comparison. Extending it to the field of environment, we can think that environmental justice is a moral evaluation of rights and responsibilities (obligations), outcomes and inputs by people in the process of utilizing environmental resources.

Regardless of group differences and intergenerational factors, from the perspective of regional environmental justice, environmental justice can be measured with the ratio of economic benefits received by different regions to the environmental costs they bear in the process of development. If the ratio is equal, it indicates that the two regions have realized environmental justice. That is to say, the degree of environmental justice is the absolute value of the difference in environmental justice between two regions:

$$K = \left|GDP_i/P_i - GDP_j/P_j\right| \tag{16.2}$$

Where GDP_i is the GDP output of region I, which indicates the economic benefits that are received, and P_i is the total pollution of region I, which indicates the environmental costs that are borne. K is the injustice index between two regions, which equals the absolute value of the difference in environmental justice between the two regions. If $K = 0$, it means that the two regions have realized environmental justice. But if $K \neq 0$, it means that the two regions haven't received environmental justice. The larger K is, the more environmental injustice there will be.

To eliminate the disparities of environmental capacity caused by regional disparities, the formula for environmental justice index in this paper is used to calculate the economic benefits generated per unit of pollution:

[3] Wang Jiawei, Behavior Science [M], Hangzhou: Zhejiang Education Publishing House, 1996: p.121.

$$EJ_i = \Pi_i / P_i / S_i \tag{16.3}$$

in which EJi is the environmental justice index, Πi is the total regional economic output of region I, Pi is the environmental pollution of region I and Si represents the size of land used for total economic output. The higher EJ is, the lower the environmental cost for the same amount of economic benefits in the region will be.

16.3.2 Assessment of Environmental Justice Under Regional Disparities in Jiangsu

In this paper, we choose the industrial pollution discharge/emission indexes (equivalent), industrial added values (in RMB 10,000) and the land used (in km^2) of 13 cities in 1998 and 2005 to calculate the environmental justice (data source: Statistical Yearbook of Jiangsu Province and the Environmental Statistical Bulletin of Jiangsu Province in 1999 and 2006). Amongst, the industrial added values were the constant-price values of 1978, and the environmental pollution discharge/emission indexes are expressed in equivalent of pollution discharge/emissions.

16.3.2.1 Environmental Injustice Exacerbates

Figure 16.1 displays the environmental justice indexes of 13 cities of Jiangsu Province in 1998 and 2005. It shows that the environmental justice indexes of Southern, Central and Northern Jiangsu changed significantly from 1998 to 2005. Particularly, the one of Southern Jiangsu more than doubled on average. Amongst, the index of Zhenjiang rose from RMB 0.456 million/equivalent • km^2 to 3.308 million/equivalent • km^2, which represented an increase of more than 7.2 times. In Central Jiangsu, except for Yangzhou which demonstrated a slow increase, Taizhou and Nantong registered an increase of 200 % in the environmental justice index. In Northern Jiangsu, due to the relative slow economic development, the industrial added value for pollutant discharge/emissions per unit area didn't grow significantly. Amongst, the index of Lianyungang fell to 50 % of the original value and the index of Suqian remained flat. Generally, as the economy grows rapidly, the degree of environmental injustice exacerbates.

16.3.2.2 Environmental Injustice Varies Significantly from Region to Region

The environmental injustice indexes of 13 cities are classified with the cluster analysis method. The result of distribution is shown in Fig. 16.2.

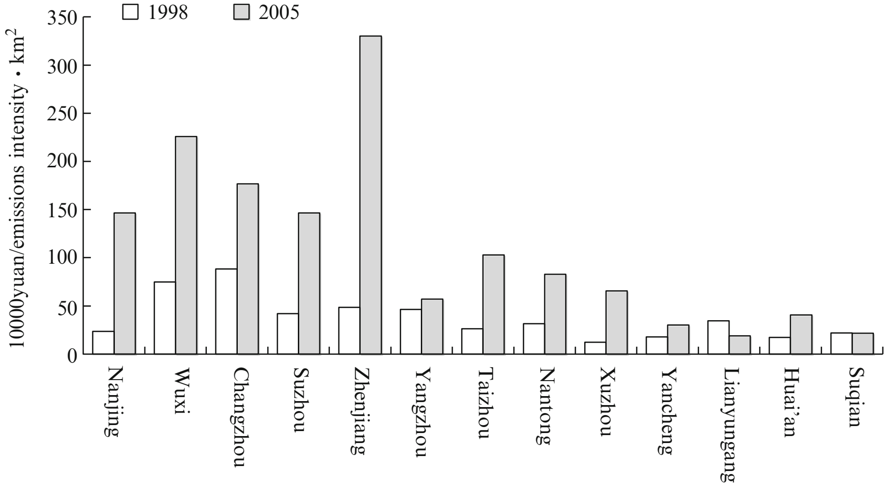

Fig. 16.1 Comparison of environmental equity index for 13 cities of Jiangsu in 1998 and 2005

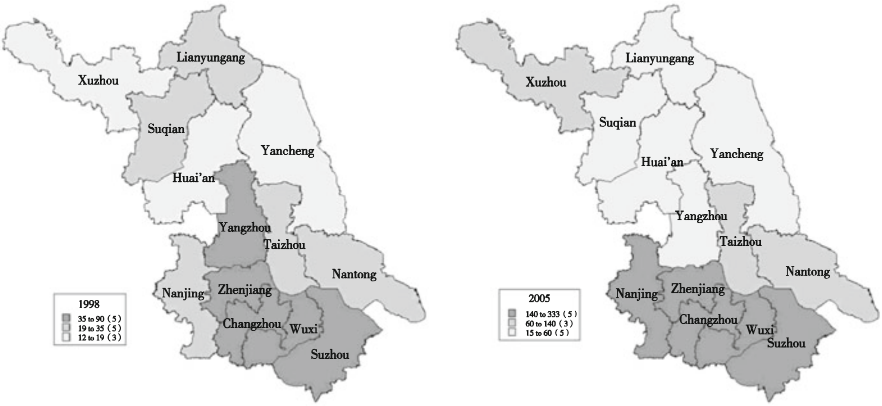

Fig. 16.2 Distribution of environmental injustice indexes of 13 cities of Jiangsu in 1998 and 2005

In 1998, the environmental injustice indexes of Southern, Central and Northern Jiangsu didn't quite match the administrative division and were disorderly distributed. This was because Jiangsu environmental authorities launched a series of environmental protection campaigns in the year, including shutting down 15 categories of small and high-polluting enterprises and carrying out water pollution control in Taihu Lake. As a result, the air pollution in some heavily pollution areas in Northern Jiangsu was significantly improved, and the water pollution in Southern Jiangsu was reduced. In 2005, the distribution of environmental injustice indexes displayed significant disparities between the three regions. The environmental justice indexes of five cities in Southern Jiangsu were the highest, all above RMB 1.4 million/equivalent • km^2. In Central Jiangsu, except for Yangzhou, the environmental justice indexes of all cities were above RMB 0.6–1.4 million million/equivalent • km^2. In Northern Jiangsu, except for Xuzhou, the environmental justice indexes of all cities were below RMB 0.6 million/equivalent • km^2. So the degree of environmental justice varies significantly among the three regions.

16.4 Proposals for Regional Coordinated Development

We should, by adopting a series of environmental and economic control policies, narrow the inter-regional environmental injustice so as to ultimately attain the goal of regional coordinated development.

16.4.1 Provide Space Control for Ecological Environment

As an effective and appropriate means to adjust the allocation of resources, space control first emerged in the U.S (Li Zongyao et al. 2007). It emphasizes that the policy orientation of human activities refers to reasonably organizing, regulating and controlling the direction, intensity and speed of human activities so that the regional ecological environment can avoid obvious degradation in large temporal and spatial scales or even continuously improve. It can combine with regional development requirements, or simply serve ecological protection or facilitate the construction of a regional ecological security pattern. In this process, the government should, as the control subject, comprehensively determine the value of natural ecosystems and the use value, provide classified protection for natural ecological spaces according to their levels of importance, guide and control human activities in different control areas so as to limit human intervention within the scope of ecosystem self-regulation.

16.4.2 Speed Up the Implementation of an Ecological Compensation Scheme

The implementation of strategies that encourage imbalanced development widens the economic disparities between different regions. As a result, people who get rich first in developed regions enjoy more economic benefits while people in less developed regions bear more environmental risks and burdens. In market economy, environmental beneficiaries won't voluntarily return the benefits they receive. Ecological compensation schemes are designed to, by planning, legislative and market means, address the interest compensation of downstream regions to upstream regions, developed areas to protected areas and beneficiary areas to areas that suffer losses. The ecological compensation of urban areas to rural areas and the rich to the general public must be addressed by levying compulsory environmental taxes, establishing environmental funds and adopting a system of financial transfer payment. In general, we should adopt well-established environmental payment and taxation policies so that more money can be obtained from the high income earners to improve the environment, the low income earners can enjoy more environmental benefits, producers can voluntarily adopt environment-friendly production technologies and consumers can choose an environment-friendly consumption pattern.

16.4.3 Establish a Governance Performance Evaluation System to Environmental Protection

In China, a lot of resources and energy are consumed, resulting in the growth of the economy on one hand and serious damage to the ecological environment on the other. Severe environmental degradation occurs from time to time. Moreover, the performance of local government is now assessed simply by economic indexes. This further enhances the impulse of local governments to pursue one-sided economic growth. Therefore, we should adhere to the scientific outlook on development and establish a governance performance assessment system that is beneficial to environmental protection. This system should not only include economic growth indexes, but also incorporate public environmental quality assessment, changes in air quality, changes in drinking water quality, increase in forest coverage, growth in environmental investment, occurrence of public environmental appeal incidents, implementation of environmental laws and regulations by local governments and other environmental protection indexes so as to promote the transformation of government functions from simply pursuing economic growth to facilitating coordinated social, economic and environmental development and avoiding environmental deterioration. Eventually, we should strive to minimize the resource consumption and pollution per unit of GDP and maximize the full-load productivity of each laborer in the region and the economic aggregate carried by each unit of land area.

16.4.4 Enhance Watershed-Specific Management of Environmental Pollution

Administrative division always considers political, economic, natural and ethnic factors. The radiation effect of cities is more important. Developed regions are capable of coordinating regional development and promoting regional equality. As the economy grows, we gain not only the experiences in which developed regions bring along less developed regions for shared prosperity, but also the lessons in which regional disparities widen due to the concentration of ecologically vulnerable regions in the same administrative region. We should, according to resources, population, economic aggregates and different ecological functions, define different goals, set up different criteria, adjust the administrative division and optimize the allocation of different resources. The division of one or two relatively complete natural areas into one administrative region, particularly with water systems as borders, can facilitate the unified development of water and land resources in the region, the coordination of compensation between downstream and upstream regions, and more importantly, the overall planning and management of the environment.

16.4.5 Adopt a Series of New Economic Policies

First, we should develop a recycling economy, because it can not only relieve the resource and environmental pressure of Southern Jiangsu, but also solve the problem of employment in ecologically vulnerable regions in Central and Northern Jiangsu. Under traditional development patterns, technological progress will result in the decrease of employment. The recycling economy, due to the extension of production chain and development of waste resource recycling, can increase work opportunities. In the U.S., the waste resource recycling industry contributes $236 billion of GDP and provides 1.1 million jobs a year, which is equivalent to the auto industry. Second, we should adopt environmental policies in line with inter-regional differences. The eastern, central and western parts of China vary significantly in term of resources, climates and potential environmental capacity. To facilitate fair development, we can adopt different environmental criteria when defining pollution charge rates, allocating total pollution discharge/emission and determining the environmental tax threshold. Third, we should encourage ecological migration. The important ecological function zones, ecologically vulnerable zones and poorest areas are mostly located in Northern Jiangsu. In this context, we should relocate residents in these areas to cities in Southern Jiangsu which should allocate areas to build economic development zones for ecological migrants from Northern Jiangsu. Local governments should build infrastructure in the development zones and provide skill training for the immigrants. They should also consider the environmental capacity and develop green industries. **On top of that,** they should, by making integrated poverty relief and environmental protection plans, draw on the success experience of ecological agriculture and ecological industry.

In addition, we should establish an environment-first concept and make it a criterion to judge right and wrong and a rule of behavior to guide the public to live a new environment-friendly way of life that pays more attention to the care of others and spiritual transcendence. Besides, we should, by changing the pattern of consumptions, guide major transformation of production patterns and adjust the industrial structure to make it a regulator for the distribution of productivity and allocation of environmental resources, and a new lever for regional coordinated economic and environmental development.

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Chapter 17
Impact of Ecological Landscape on Housing Prices in Urban Residential Districts – A Case Study of Mochou Lake in Nanjing

Wu Dongmei, Zhongxing Guo, and Chen Huiguang

17.1 Introduction

Livability is the most fundamental requirement of men, and the environmental quality is the most important condition to ensure livability. As the economy develops, men's requirements for the living environment get increasingly demanding. When property developers bid for target land lots or sell houses, or when consumers make purchase decisions, they would all pay much attention to the ecological landscape in the residential districts. According to relevant research, green space, water systems and other urban environmental factors significantly improve the basic living conditions in urban areas. Particularly, the natural ecological landscape in vicinity of residential districts increases the value of living amenity. However, due to its externality and non-commodity, ecological landscape is hard to monetize, and its intangible benefits to cities and nearby residents can hardly be estimated and quantified. As a result, its significance to cities and residents' benefits is often ignored by city planners or policy makers. Consequently, benefits that belong to the public are seized by some special interest groups. As the ecological landscape can affect the supply and demand in the residential market, property buyers are willing to pay extra money for landscape viewability. In most foreign research literature, the Hedonic price model is used. But in China, most scholars pay attention to assessing the natural attributes of ecological landscape, and the Hedonic price model is seldom used to manifest the value attributes of ecological landscape. Particularly, it is so for the research on the value of ecological landscape of point source attribute. In this paper, we will, based on the theoretical analysis of the impact of ecological landscape on the supply and demand in

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residential market, apply the Hedonic price model to study the impact of the landscape of Mochou Lake in Nanjing on housing prices.

17.2 Impact of Ecological Landscape on Residential Market

As the ecological environment gets increasingly scarce and the demand of green consumption grows rapidly in urban areas, the impact of urban ecological environmental quality on nearby residential market will become more and more important. Generally speaking, the impact of ecological landscape on residential market is mainly displayed on supply and demand, and eventually the impact on the equilibrium price in residential market.

17.2.1 Impact of Ecological Landscape on Supply

As real estate developers are highly dependent on urban ecosystems, their operational activities will surely be affected by the conditions of ecological resources in urban areas. In modern real estate markets, sensitive developers have realized the huge demand of sound living environments. In addition, sharp-sighted developers make optimal marketing strategies in line with different types of landscape and their values. But due to the peculiarity of ecological landscape, location attributes and the derivative spatial distribution characteristics, the supply of houses in ecological landscape areas is quite limited. That is to say, the supply curve of such houses is on the left of the supply curve of general houses.

17.2.2 Impact of Ecological Landscape on Demand

Compared with general commodities, houses can not only meet the living demand of consumers, but also bring environmental enjoyment to them, namely environmental amenity value. In addition, as a type of real estate, houses can also bring value increment to investors. The demand of "green" houses is in nature a pursuit for a better life. Due to the scarcity of environment and the amenity value, people living in residential districts with better ecological landscape display a higher social status and better career achievements, which brings extra utilities in addition to living, value increment and environmental amenity to consumers. But the income of consumers and other features affect their effective demand of houses with good ecological landscape. High income earners prefer houses with sound environments and are willing to pay more than the average housing prices. In this context, the surrounding ecological landscape is an important factor for them to consider when purchasing properties.

The above analysis indicates that the suppliers and demanders of commercial houses approve of the value of ecological landscape and internalize it into housing prices. Buyers are willing to pay extra for amenity and other subjective values, internalize the externalities, including the ecological landscape that can be reflected by objective housing prices, thus partially remedying the market malfunction caused by positive externalities.

17.3 Application of Hedonic Pricing Model to Assess the Impact of Environmental Landscape on Housing Prices

17.3.1 Definition and Principle of Hedonic Price Method

In the academic community, it is deemed that the Hedonic price method is based on the consumer theory proposed by Kelvin J. Lancaster in 1966, the market supply and demand equilibrium model put forth by Sherwin Rosen in 1974 and other theories. Hedonic originally means pleasure-related. Here it means that housing prices are determined by the coefficient value of attributes and the pleasure (i.e. utilities) brought by attributes to consumers. Hedonic price method is also translated into characteristic analysis method. According to this method, houses are made up of many complex attributes, prices are determined by utilities brought by all attributes to people, and the number of attributes and different combinations will lead to differences in housing prices. Therefore, by analyzing the marginal returns of all attributes, i.e. the marginal expenses that consumers are willing to pay for unit attribute of different types, we can assess the implicit price, namely Hedonic price of such attributes. In previous studies, related attributes are grouped into three categories, i.e. location, structure and neighborhood. Also, according to the characteristics of residential commodities, the prices are broken into prices of characteristics according to the heterogeneity of houses, and implicit prices of characteristics are estimated according to the market transaction data. Table 17.1 lists the variables used in related Chinese and foreign studies.

17.3.2 Application of Hedonic Price Method

Many foreign scholars use this method to assess the Hedonic price of some environmental goods in the housing market, and then estimate the impacts of environmental goods (mainly parks, lakes, mountains, green space and urban open space), air pollution, refuse landfills and other environmental factors on

Table 17.1 Commonly used variables

Types of variables	Commonly used variables
Location	Distance to CBD, bus stations, distance to sub-city centers, road accessibility and types, distance to airports, railway stations and ports, etc.
Structure	Age, area, floor, number of bedrooms and bathrooms, orientation, garage, storage rooms, attics, fireplaces, etc.
Neighborhood	Quality of schools, natural landscape (mountains, water, etc.), degree of air pollution, noise, urban landscape (manmade parks, green space, etc.), amenities, graveyards, golf courses, crime rate, refuse landfills, etc.

Note: The measurement of landscape variables includes the type of landscape, scale, distance to houses and quality

housing prices. Chinese scholars Wen Haizhen et al. (2003) used 239 houses in Xihu (West Lake) District of Hangzhou in December of 2002 to establish a characteristic price model, and conducted empirical analysis of the impact factors. Some scholars used a characteristic price model to analyze the housing prices in Guangzhou and Jinan. Their studies indicate that good environments and perfect infrastructure have a significant positive impact on housing prices, while environmental pollution has a significant negative one.

17.4 Empirical Analysis

In this paper, we will use the Hedonic price model to analyze the price structure of houses around Mochou Lake in Nanjing, particularly the proportion of ecological landscape in housing prices, and separate the value of ecological landscape from housing prices.

17.4.1 Selection of Study Area

As the residential market is a special commodity market with strong regional characteristics, the focus on samples in a specific region can, to some extent, avoid deviations caused by market segmentation. In this paper, the Mochou Lake area which is 1.5 km away from Shuiximen of Nanjing is selected as the study area. In this area, the Mochou Lake Park covers a space of 54 hm^2, and the area of Mochou Lake is about 33.3 hm^2. Since ancient times, this lake has been well reputed and regarded as the First Famous Lake in the south of the Yangtze River and the First of 48 scenic attractions in Nanjing. Residential buildings in the Mochou Lake area were mostly built in 2001–2005. It is now a well-developed high-grade residential area in Nanjing. In this paper, six residential districts in the area, namely Ming Hu Ya Ju, Jin Se Jia Yuan, Zuo Lin Feng Du, Jun Yuan, Xin

Table 17.2 Characteristics of sample residential districts

	Ming Hu Ya Ju	Jin Se Jia Yuan	Zuo Lin Feng Du	Jun Yuan	Xin Cheng Yi Jing	Wei Lan Zhi Du
Opening date	August of 2004	June of 2003	August of 2004	July of 2005	March of 2004	September of 2005
Area ($\times 10^4$ m^2)	0.2696	5.1	1.7477	0.7786	0.2696	1.5
Floor space ($\times 10^4$ m^2)	2	14.4	5.59	1.9	2	8.1
Greening rate (%)	43	40	45	40	43	40

Cheng Yi Jing and Wei Lan Zhi Du, are chosen as study objects. Table 17.2 lists the basic characteristics of the sample residential districts.

17.4.2 Model Selection

17.4.2.1 Basic Model Form

According to Richard V. Butler, the Hedonic price model should only include factors that affect housing prices. Factors affecting housing prices normally fall into three categories, namely location, structure and neighborhood. So the housing price function can be expressed as: $P = f(L, S, N)$.

This price function is considered as the general function form of the Hedonic price method. Because the relations between housing prices and the characteristics of houses and the surroundings are quite complicated, multiple functions can be used for comparative analysis. In this paper, linear and semi-logarithmic functions are used.

17.4.2.2 Selection of Variables and Theoretical Expectations

As housing prices focus more on reflecting the purchasing power of consumers, the apartment prices in the second-hand housing market are used as dependent variables in this study. Although some studies show that the property fee has a significant impact on housing prices, because the property fee, greening rate and number of schools of the six residential districts in the study area are close, and they will not cause much difference in housing prices, these variables are not considered in this study. Independent variables are mostly other location, structure and neighborhood characteristics.

Location

The location has a significant impact on housing prices. When living in highly populated areas close to CBD, people pay more attention to the value of ecological landscape. As all the residential districts in the Mochou Lake area are not quite different in term of distance to CBD, sub-city center, airport, railway station and the wharf, so the impact of these factors can be ignored. Therefore, the location difference of residential districts in this area is mainly reflected by public traffic which can be quantitatively measured with the number of bus routes, distance to bus stations and traffic at bus stations. In this paper, the number of bus routes within a perimeter of 500 m is used. Generally speaking, the more bus routes there are, the more convenient it is for residents, and the more significant the location characteristic is.

Structure

The size of houses, number of bedrooms, number of bathrooms and size of sitting rooms are variables for measuring the structure characteristics, which to some extent represent the housing structure. Generally speaking, the larger the house is, the more expensive it is. The impact of floor on housing prices is quite complicated. In a multi-floor building, the price of houses on middle floors is the higher. In a high-rise building, the prices of houses on top floors are higher because of better daylighting, ventilation and view conditions. Decoration has a direct impact on housing prices. The more luxurious the decoration is, the higher the housing prices will be.

Residential buildings involved in this paper fall into high-rise and multi-floor buildings. Generally speaking, the building costs of high-rise buildings are higher than those of multi-floor buildings, so their prices are relatively higher. Better orientation results in better daylighting and ventilation. Therefore, its expected impact on housing prices is positive.

Intuitively speaking, housing prices will change in response to plot ratio. When the plot ratio increases, housing prices will go up before dropping. Therefore, whether its impact is positive or negative can hardly be determined. As buyers trust that reputed brand developers can deliver better quality, the expected impact on housing prices will be positive.

Neighborhood Landscape

Houses adjacent to streets are polluted by noise and dust. Therefore, their prices are generally lower. Although landscape variables are hard to be accurately defined, Luttik (2000) argued that we should look at how residents perceive the landscape viewability and recreation. Amongst, landscape may have the biggest impact on aesthetic appreciation. Therefore, it can be measured by landscape viewability and

Table 17.3 Selection of variables and expected symbols

Variable		Expected symbol
Location (L)	X_1: Number of bus routes	+
Structure (S)	X_2: Area (m^2)	+
	X_3: Number of bedrooms	+
	X_4: Number of sitting rooms	Unknown
	X_5: Number of bathrooms	Unknown
	X_6: Decoration standard	+
	X_7: Floor	–
	X_8: Housing type	–
	X_9: Orientation	+
	X_{10}: Plot ratio	+–
	X_{11}: Brand of developer	+
Neighborhood landscape (NL)	X_{12}: Whether overlooking streets (dummy variable)	–
	X_{13}: Lake viewability (dummy variable)	+
	X_{14}: Access to the lake (dummy variable)	+
	X_{15}: Distance to the lake (m)	–

direct distance to landscape. Moreover, in addition to the above two factors, the impacts of Mochou Lake landscape on surrounding residential districts also include whether there is direct and free access to the lake. Among all the six residential districts in the study, Jin Se Jia Yuan developed by Vanke is directly built on the lake, so its owners have free and direct access to the lake. This is also one of the most significant factors that differentiate this residential district from others in this study. Therefore, in this study, mainly three types of landscape variables are used, namely whether it is possible to view the lake in the houses, whether there is free and direct access to the lake in the district and the shortest distance to the lake. Some foreign studies show that people are willing to pay more for enjoying lake landscape. Therefore, the expected symbols of landscape viewability and direct access to lakes are positive, while the expected symbol of distance is negative.

In summary, the independent variables to be used in this study and their expected impacts on housing prices are listed in the following table (Table 17.3).

17.4.2.3 Data Source and Quantification

Data used for the empirical study mainly falls into three categories, namely, listed data, survey data and the electronic map data provided by Google Earth.

The listed sales data stems from the online house information in Nanjing. It is used mainly because the transaction data directly obtained from Nanjing Real Estate Transaction Center, Nanjing Real Estate Administration and other relevant authorities contains less information and it is hard to get the real transaction data from developers to meet the requirements for this study. Moreover, such data mainly uses the data between June and November of 2007. This can reduce the deviation of model coefficient estimation caused by time differences.[1]

The listed sales data fails to reflect the current conditions of residential districts, such as the surroundings and the number of bus routes. Therefore, a detailed field survey was conducted for the six residential districts in the study area. The data was also further verified through intermediary agencies.

The electronic map data provided by Google Earth was used to measure the distance variable of landscape. Through the electronic map, the shortest distance from the residential districts to Mochou Lake was measured.

There are a total of 15 location, structure and neighborhood landscape variables, which can be quantified in the following three methods:

1. Using the actual value of variables, such as number of bus routes, floor space, number of rooms, number of sitting rooms, number of bathrooms, floors and distance to the lake;
2. Assigning a value to the variable. The variable that is quantified with this method is the decoration degree: deluxe (3 points), exquisite (2 points), simple (1 point) and rough (0 point);
3. Using dummy variables. Variables that are quantified with this method include: type of house (1 for houses in a multi-floor building and 0 for houses in a high-rise building), orientation (1 for houses facing south and 0 for houses facing other directions), whether the house overlooks the street (1 for yes and 0 for no), lake viewability (1 for yes and 0 for no), free access to the lake (1 for yes and 0 for no) and developer's brand (1 for famous and 0 for not famous).

When adopting the Hedonic model for study, the number of samples must be guaranteed. Generally speaking, the number of samples must be at least 3 times the number of variables. After the samples whose information is incomplete and listed sales prices that have significant deviations are eliminated, a total of 190 apartments are used as samples in this study.

[1] Theoretically, adopting the transactions prices at the same time for model fitting is the most ideal practice. But it is very hard to obtain transaction price data in reality. In most cases, we need to choose proxy variables for a certain period of time. Although the listed sales data has some deviations, the fitting of transaction prices provided by a real estate agent in Nanjing and the listed sales prices (49 samples) in 2006 indicated that the correlation coefficient between them is up to 0.97. Therefore, it is appropriate to use the listed sales data as the proxy variable. In addition, a large quantity of listed sales data in a relatively concentrated period of time can reduce the deviations caused by asset appreciation.

17.4.3 *Results and Discussions*

17.4.3.1 Model Results

In this paper, linear and semi-logarithmic models are respectively used for regression analysis of the above explanatory and explained variables. The model results are as follows:

In the semi-logarithmic model, dependent variables are in the form of logarithm, and except for the distance variable which is in the form of logarithm, all the other 14 independent variable are in linear form. From the above table, we can see that the overall fitting degree of linear functions is worse than that of semi-logarithmic functions, and the number of significant variables is smaller than that of semi-logarithmic functions. Therefore, in this study, semi-logarithmic functions are used as the final functions for further analysis and verification.

As there is multi-collinearity between some variables, after insignificant variables are gradually eliminated, the final model estimation result is as follows:

First, according to R^2 derived after the estimating equation is adjusted, the overall fitting capacity of the equation is satisfactory. Nearly 90 % of the variances of explained variables can be explained with explanatory variables. Second, with regard to the *T* test value of all variable coefficients, the estimated coefficient of all variables are significantly to be non-zero, and significant at 1 %. Moreover, the D-W value is 1.83, close to 2.0. Therefore, we can conclude that errors in the model are independently, and are not auto correlated.

17.4.3.2 Result Analysis

(1) Symbolic analysis of housing characteristic prices. Results of Table 17.4 indicate that the floor space, number of bedrooms, decoration degree, type of house and plot ratio have a significant impact on housing prices. This conforms to the theoretical expectation. Amongst, the impact of decoration on housing prices complies with the study result of Ma Sixin and Li Ang (2003). The primary regression result of the semi-logarithmic functions indicates that all variables conform to the expected symbol, except that orientation, number of bus routes and distance to the lake are contrary to the expected symbol. The diagram of the study area shows that, due to the orientation to Mochou Lake, houses in Jin Se Jia Yuan and Wei Lan Zhi Du basically face southwest to ensure lake viewability. In Ming Hu Ya Ju and Zuo Lin Feng Du, only houses facing north can provide lake viewability. Therefore, orientation is insignificant in this study, and there is a negative relationship between it and housing prices.

Traffic conditions of the area in which residential districts are located also have an important impact on housing prices. Generally speaking, the more bus routes there are, the higher the mobility is. However, the result of Table 17.4 doesn't conform to the theoretical expectation. This may be because residential districts in this area are all upscale districts where many residents own private cars. While

Table 17.4 Primary model results

		Linear	Semi-logarithmic
		Estimated coefficient	Estimated coefficient
Location variable	X_1	10.003	−0.003
		(0.969)	(−0.338)
Structure variable	X_2	1.728***	0.006***
		(8.701)	(9.020)
	X_3	22.345**	0.092***
		(2.401)	(3.170)
	X_4	18.145	0.016
		(1.643)	(0.467)
	X_5	0.917	0.046
		(0.097)	(1.559)
	X_6	13.869***	0.038***
		(4.089)	(3.604)
	X_7	0.248	−0.002
		(0.453)	(−0.925)
	X_8	28.955	−0.191***
		(1.637)	(−3.474)
	X_9	1.683	−0.001
		(0.184)	(−0.043)
	X_{10}	25.961	−0.053
		(0.731)	(−1.410)
	X_{11}	−380.893	0.283
		(−1.054)	(0.579)
Neighborhood landscape variable	X_{12}	−34.729***	−0.127***
		(−3.491)	(−4.100)
	X_{13}	19.196**	0.116***
		(2.303)	(4.476)
	X_{14}	328.181	0.280
		(1.358)	(1.404)
	$X_{15}/log(X_{15})$	−1.323	0.162
		(−0.944)	(0.792)
C (Constant term)		−106.363**	3.361***
		(−2.293)	(4.008)
R^2		0.8384	0.9065
Adjusted R^2		0.8245	0.8984
F		60.20	112.52
D-W		1.9318	1.8358

Note: *** indicates that the *T* test value is significant at 1 %, ** indicates that the *T* test value is significant at 5 % and * indicates that the *T* test value is significant at 10 %

Table 17.5 Final model results

		Estimated coefficient
Structure variable	X_2	0.006***
		(10.505)
	X_3	0.087***
		(3.172)
	X_6	0.034***
		(3.285)
	X_8	−0.213***
		(−4.509)
	X_{10}	−0.040***
		(−4.034)
Landscape variable	X_{12}	−0.121***
		(−4.013)
	X_{13}	0.121***
		(5.079)
	X_{14}	0.283***
		(9.108)
C (Constant term)		4.153***
		(72.894)
$R^2 = 0.902$ Adjusted $R^2 = 0.898$ F = 209.383		
D−W = 1.833 Prob(F) = 0.000		

Note: *** indicates that the *T* test value is significant at 1 %, ** indicates that the *T* test value is significant at 5 % and * indicates that the *T* test value is significant at 10 %

improving mobility for residents, buses will increase air pollution and noise pollution. Therefore, this variable is negatively insignificant in this study area.

The variable of distance to the lake is insignificant because it adopts the shortest distance from residential districts to the lake rather than the distance from apartments to the lake, and the difference between samples is quite small. Moreover, the influence perimeter of the landscape is normally around 1000 m [25,26], and the longest distance from residential districts to the lake in this study is only 250 m. The small study range and minor difference between samples may be another reason why the variable of landscape distance is insignificant.

From the final model result of the Table 17.5, we can see that among the landscape variables, except that the distance to the lake is insignificant and is not included in the final model, the other two models are included in this model; the *T* test value is significant and conforms to the expected symbol.

(2) Price elasticity analysis of landscape variables. In the semi-logarithmic model, the regression coefficient is a coefficient that is not normalized, which corresponds to the proportionate variation or relative variation in housing prices, or rather the growth rate, caused by absolute variable changes. But because the independent variables are not continuous variables, the value of regression coefficient can't be directly used but needs to be processed. The percentage variation is deduced from the antilog of the regression coefficient. In this section, a detailed

Table 17.6 Price elasticity of landscape variables

Landscape variable	Estimated coefficient	Elasticity coefficient (%)	Semi-elasticity/regression coefficient	Marginal price
X_{13}	0.121	12.81	1.063	15.89
X_{14}	0.283	32.77	1.156	40.65

price elasticity analysis is conducted for landscape variables. See Table 17.6 for the results. The variable coefficient of lake viewability is 0.121 and the elasticity coefficient is 12.81 %. This indicates that the total price of houses providing viewability of Mochou Lake is 12.81 % higher than that of other houses. As the average total price of houses in the study area is RMB 1.9464 million, the total price of houses providing viewability is about RMB 0.2494 million higher. The unit price of houses in the study area is RMB 15,700/m^2, the unit price of houses providing viewability is about RMB 2011.17 higher.

The variable coefficient of direct-and-free access to the lake is 0.283486. This indicates that the total price of houses with direct-and-free access to the lake is 32.77 % higher. As the average total price of houses in the study area is RMB 1.9464 million, the total price of houses with direct-and-free access to the lake is about RMB 0.6378 million higher. The unit price of houses in the study area is RMB 15,700/m^2, the unit price of houses with direct-and-free access to the lake is about RMB 5144.89 higher.

This shows that the lake landscape dramatically enhances the environmental quality and improves the living amenity value. Therefore, the landscape variable can significantly increase the value of houses.

17.5 Brief Conclusions, Policy Implications and Discussions

Environmental quality, ecological landscape and other non-market commodities, due to their externalities, can provide close-range lake landscape amenity, but they don't have open-market objective values. However, with the Hedonic price method in revealed preference (RP), they can be manifested as extra money that people are willing to pay for lake landscape, thus separating the amenity value, ecological service value, non-use value and other subjective values from the listed sales data. Results of this paper indicate that the lake landscape can significantly improve the environmental quality and increase the living amenity value. The lake landscape amenity value or ecological service value takes up a large proportion of around 13 % in the housing prices. This gives rise to several policy implications.

1. The assessment of amenity value and other subjective values is different from that of objective values. The empirical study shows that the Hedonic price method is applicable to the valuation of properties in China. With this method, we can calculate the value of urban ecological landscape and other non-marked

commodities, and improve the valuation system of land prices and housing prices in urban areas. Results of this study can provide new approaches for developing and pricing real estate, as well as a theoretical and practical foundation for both parties of transactions to assess the subjective values.

2. Internalization of externalities of ecological landscape and non-commodity monetization. From this empirical study, we can see that the impacts of landscape on surrounding houses are mainly embodied by landscape viewability and free access to lakes. Externalities should not establish exclusiveness by charging development activities of surrounding residences. The ecological value is radiated in a larger scope, and the value added to housing prices due to ecological landscape should be owned by developers. The Hedonic price method should be adopted to monetize and manifest the value of ecological landscape or a "pigovian tax" (environmental tax) should be levied to internalize the externalities. Whether an environmental tax should be levied is not included in the discussion here. Instead, it should be further demonstrated and assessed.
3. The urban ecological landscape has a significant impact on housing prices. The role of urban ecological landscape in increasing surrounding housing prices should be taken into full consideration. The study results can be used as reference for urban regulatory planning and land planning. Landscape ecology has already provided a foundation in this regard. The combined assessment of natural and value attributes of landscape enables more efficient land utilization and more reasonable urban space planning.

This model has a better fitting effect. But in term of variable selection, value assignment standard and method, this paper still has some defects: due to data accessibility, only residential districts around Mochou Lake are selected for a relatively simple analysis. The Mochou Lake area is not comprehensively compared with other heterogeneous areas with lake landscape. Therefore, the applicability of the study result is quite limited. With regard to variable selection, because the listed sales prices mainly represent or embody the assessment of ecological landscape by sellers, and they can't reflect the willingness of buyers to pay for ecological landscape, when the listed sales price and transaction price are used as the variable, the result and implication will be different. Moreover, as the study area only covers a few adjacent residential districts, the neighborhood and location characteristics are quite similar and can hardly be differentiated.

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Chapter 18
Coupling of Ecological Economic System in Tarim River Watershed

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Coupling refers to the objective characterization of the mutual stress and interdependence relations between systems and between elements within the systems. It depicts the evolution or trend of the regional ecological economic system in a certain period of time. The development of a regional ecological economic system mainly depends on the regional comprehensive ecological environmental supporting capacity, regional socio-economic development, and the mutual coordination and coupling between the two aspects. Coupling of the ecological economic system is a spiraling process in which the concept of physics coupling is used to describe the interaction and mutual stress between comprehensive ecological environmental supporting system and regional socio-economic development system to ascend from low-level coordination to high-level coordination. In this paper we will, on top of building an assessment index system, use a quantitative assessment model to demonstrate the coupling of the ecological environment system in Tarim River Watershed and analyze the coordinated coupling and dynamic changes of the ecological environment system so as to provide theoretical reference for sustainable development of the watershed.

18.1 Profile of Study Area

Tarim River Watershed is in the south of Xinjiang, between the Tianshan Mountain and the Kunlun Mountain. Running about 1100 km from the east to the west and 600 km from the south to the north, it is the largest inland river watershed in the world. From the longest origin Yarkant River to Taitema Lake at the tail, Tarim

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River is 2437 km long. Tarim River Watershed is surrounded by the southern slopes of the Tianshan Mountain, the Kunlun Mountain and the Altun Mountain. In the middle of the watershed is Tarim Basin. The watershed is ruled by typical warm temperate continental climate characterized by drought, wind, huge temperature differences between day and night, scarce precipitation and strong evaporation. In the center is the Taklimakan desert which inclines inward to the piedmont sloping plain at the edge. In this vast area are mountains, oases, natural vegetation and deserts, where the ecological environment is quite vulnerable. The gross amount of water resources in the watershed is up to 42.9 billion m^3, and the size of farmland is 1.6 million hm^2. Abundant with water, land, heat and biological resources, as well as underground oil and gas reserves, it is an important water and land development area and agricultural base for cotton growing in China.

Tarim River Watershed covers five prefectures, including Bayingolin Mongol Autonomous Prefecture, Aksu Prefecture, Kashgar Prefecture, Kergez Autonomous Prefecture of Kizilsu and Hotan Prefecture. In total, there are 42 cities, counties and 56 farms which belong to four agricultural divisions of Xinjiang Production and Construction Corps. It is home to multiple ethnic groups dominated by Uyghur. In 2005, this area has a population of 9.43 million, including 7.77 million people of ethnic minorities. The agricultural population is up to 6.81 million. The average per capita GDP is RMB 7405, the average wages of workers is RMB 15,340 and the average per capita income of rural residents is RMB 2287, all of which are lower than the average of Xinjiang. The infrastructure in this watershed lags behind other regions. Roads and railways constitute the main means of traffic and transportation. The regional economy, technology, culture and education are less developed. Currently, the regional economy is still dominated by agriculture and animal husbandry. Crops grown in this region are mainly grain and cotton, making the watershed an important quality cotton and grain production base. The watershed is also famous for fruit and horticultural products, including Korla fragrant pears, thin-shelled walnuts, Jiashi muskmelons and figs. The industrial system is still quite weak in this region. However, the exploration and exploitation of oil and natural gas in Tarim Basin, the construction of the Kashgar-Hotan Railway and the watershed management programs will significantly facilitate the improvement of ecological environment, economic growth and social advance in the region.

18.2 Coupling Assessment Model

18.2.1 Assessment Index System and Data Processing

The assessment of the coupling of the ecological economic system involves many factors, and there are many indexes to choose from. Based on relevant studies, a system of scientific, hierarchic and feasible indexes, which can reflect the conditions of ecological economic system, is defined (Table 18.1). To unify the

Table 18.1 Assessment indexes of ecological economic system

Ecological environment subsystem f(A)	Ecological conditions 0.2384	Per capita cultivated land (hm^2/person) 0.0585	Socio-economic subsystem f(B)	Economic conditions 0.2456	Per capita GDP (RMB yuan) 0.0703
		Per capita forest and grassland area (hm^2/person) 0.0592			Per capita investment in fixed assets (RMB yuan) 0.0601
		Area of natural wetlands (hm^2) 0.0561			Economic density (RMB yuan/km^2) 0.0535
		Amount of water resources (100 million m^3) 0.0646			Per capita local financial revenue (RMB yuan) 0.0617
	Pressure of ecological environment 0.3498	Chemical fertilizer load per unit area (kg/hm^2) 0.0633		Economic development level 0.2678	Overall economic development level 0.0753
		Proportion of areas affected by disasters (%) 0.0713			Coefficient of dual economic structure 0.0678
		Emissions of industrial waste gas (100 million standard m^3) 0.0756			Investment in fixed assets /GDP (%) 0.0621
		Discharge of industrial waste water per unit area (t/km^2) 0.0789			Elasticity coefficient of per capita local financial revenue to per capita GDP 0.0626
		Industrial solid waste per unit area (t/km^2) 0.0607		Population development capacity 0.2430	Population density (persons/km^2) 0.0609
	Response and development capacity of ecological environment 0.4118	Industrial energy consumption per unit of product (ton standard coal/RMB 10,000) 0.0452			Natural population growth rate (‰) 0.0612
		Response coefficient of changes in forests and grasslands to economic growth 0.0865			Population urbanization level (%) 0.0598
		Gross product per unit area of utilized land (RMB 10,000/km^2) 0.0468			Percentage of students above middle school in total population (%) 0.0611

(continued)

Table 18.1 (continued)

		Total area of afforestation (hm^2) 0.0652		People's living standards 0.2455	Average wage of workers (RMB) 0.0614
		Rate of industrial solid wastes utilized (%) 0.0513			Per capita net income of farmers and herdsmen (RMB) 0.0605
		Area of water loss and soil erosion that's been controlled (hm^2) 0.0675			Number of doctors per 10,000 people (persons) 0.0623
		Income of tourism resources (RMB 10,000) 0.0492			Number of hospital beds per 10,000 people 0.0613

dimensions of all indexes and narrow the magnitude differences between indexes, a range normalization method is used to normalize the raw data of all indexes. The formula is as follows:

$$\text{Positive indicator}: X' = \frac{X - X_{Min}}{X_{Max} - X_{Min}} \ldots\ldots\ldots\ldots. X_{Min} < X < M_{Max}$$

$$\text{Negative indicator}: X' = \frac{X_{Max} - X}{X_{Max} - X_{Min}} \ldots\ldots\ldots\ldots. X_{Min} < X < M_{Max}$$

Where X is the value of index before being processed, X′ is the value of index being normalized, X_{Max} is the maximum value of indexes of the same series before being processed and X_{Min} is the minimum value of indexes of the same series before being processed.

The entropy method and the Delphi method are combined to determine the weights of each rule layer and index layer. The calculation process will not be detailed here.

18.2.2 Ecological Environment System, Socio-economic System and Their Evolution Velocity Models

$$f(A) = \sum a_i x_i, f(B) = \sum b_j y_j,$$

$$V_A = df(A)/dt, V_B = df(B)/dt$$

Where: f(A) is the comprehensive index of ecological environment system; f(B) is the comprehensive index of socio-economic system; x_i and y_j are respectively the normalized values of assessment indexes; a_i and b_j are respectively the index weights; V_A and V_B are respectively the evolution velocities of the ecological environment system and the socio-economic environment system; t is the time factor (t = 1, 2, 3, ...).

18.2.3 Assessment Model of Ecological Economic System Coupling

The evolution of the ecological economic system conforms to the S-shaped development mechanism, i.e. the spiral escalation mechanism. The evolution velocity V is a function of V_A and V_B. On a two-dimensional plane, a coordinate system is established with V_A and V_B as variables. Because changes in the ecological environment system are not as quick and large as changes in the socio-economic

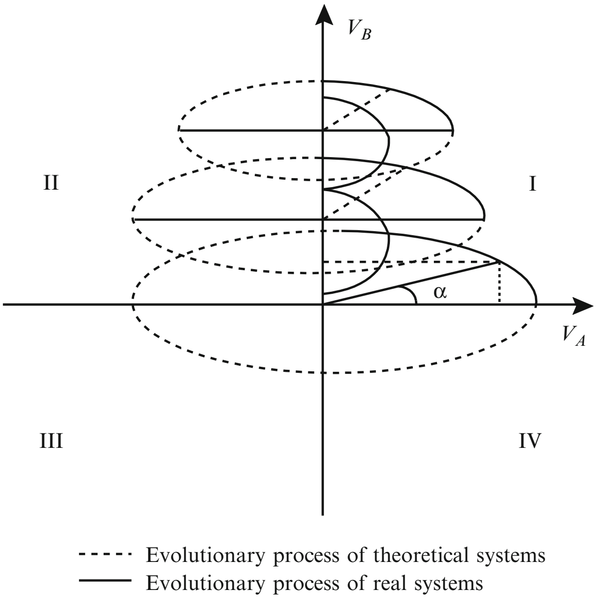

Fig. 18.1 Development process of the coupling of the ecological economic system

system, the change trajectory of V is an ellipse (Fig. 18.1). The assessment model of the system coupling is as follows:

$$\alpha = \text{arc} \ \tan \ V_B/V_A$$

Where **α** is the coupling degree of the ecological economic system.

18.2.4 Division of Coupling

Theoretically, the evolution of the ecological economic system is periodical, which is a continuous cycle from the first quadrant to the fourth quadrant. However, people often take a series of measures to intervene and control it so that its evolution resides mainly in the first quadrant. According to the value range of α, we can determine the coupling of the system (Table 18.2).

Table 18.2 Phases of system evolution

Development stage	α	Relation between V_A and V_B	Description
Underdevelopment	$0° < \alpha \leq 25°$	$0 < V_B < V_A$	Initially, too much emphasis is put on the development of ecological environment. As a result, the socio-economic development is quite slow. Under such conditions, resources and ecological environment in the region remain to be developed
Backwardness	$25° < \alpha \leq 40°$	$0 < V_B < V_A$	The socio-economy and ecological environment start to affect each other. But the advantages of resources and ecological environment haven't been transformed into economic advantages. The productivity is still relatively low
Coordinated development	$40° < \alpha \leq 55°$	$0 < V_A \leq V_B$	The socio-economy and ecological environment develop in harmony. At this point, the supporting capacity of the ecological environment can basically meet the needs of socio-economic development and resource advantages can be transformed into economic advantages. Consequently, socio-economy grows very rapidly and the ecological environment maintains a dynamic balance
Strong development	$55° < \alpha \leq 65°$	$0 < V_A < V_B$	The socio-economy starts to develop rapidly. The restraint of socio-economic development by the ecological environment gets increasingly strong, resource consumption is intensified and the protection of ecological environment is insufficient. Consequently, the system evolves toward unsustainability.
Overdevelopment	$65° < \alpha < 90°$	$0 < V_A < V_B$	Too much emphasis is put on socio-economic development, and the improvement of ecological environment supporting capacity is ignored. The system is at the verge of collapse. It can evolve in two directions. First, the contradictions between subsystems can't be reconciled and the system is about to collapse. But this violates the law of social development, so it's only theoretically possible. Second, people take measures to regulate system operation in a timely manner so it can escalate spirally toward high-level system symbiosis

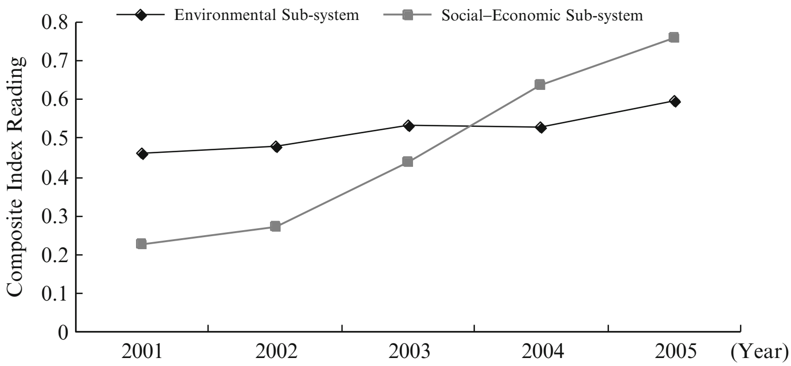

Fig. 18.2 Comprehensive ecological environment and socio-economic subsystem indexes of Tarim River Watershed

18.3 Empirical Analysis

18.3.1 Calculation of Coupling Degree

By referring to the *Xinjiang Statistical Yearbook*, *Comprehensive Statistical Book of Land Resources in Xinjiang*, *Environmental Protection Annals of Xinjiang* and other materials, the formula in Sect. 18.2.2 and weights of all indexes in Table 18.1, we can calculate the comprehensive ecological environment index f(A) and the comprehensive socio-economic system index f(B) of Tarim River Watershed in 2001–2005. See Fig. 18.2 for detailed results. Then, we can carry out non-linear simulation according to f(A) and f(B) to get f(A), f(B), V_A and V_B. The results are as follows:

$$f(A) = 0.0033t^2 + 0.0698t + 0.4063 \quad (R^2 = 0.9221)$$
$$V_A = dA/dt = 0.0033t + 0.0698$$
$$f(B) = 0.1951 \times t^{0.7967} \quad (R^2 = 0.9212)$$
$$V_{B=}dB/dt = 0.1554 \times t^{-0.2033}$$

Where, the value of t was 1 in 2001, 2 in 2002, and so on. In this way, the values of V_A and V_B can be calculated. After that, we can get the system coupling degree α according to the formula in Sect. 18.2.3 (Fig. 18.3).

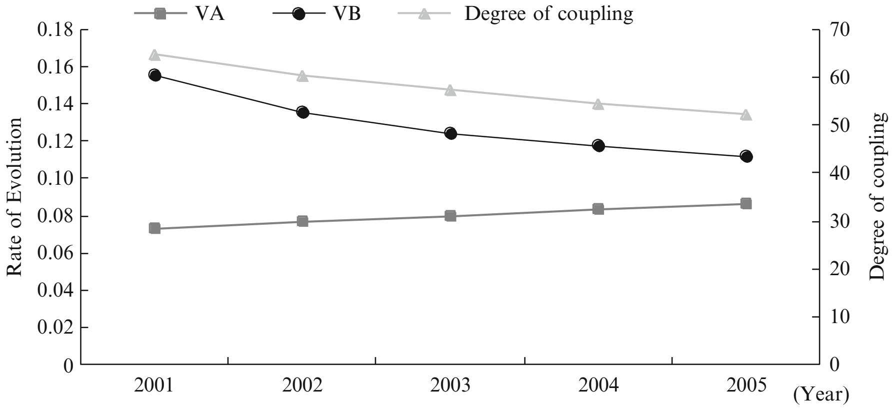

Fig. 18.3 Evolution velocities of ecological environment and socio-economic subsystems and the coupling degree of ecological economic system in Tarim River Watershed

18.3.2 Result Analysis

18.3.2.1 Analysis of Composite Index

From Fig. 18.2 we can see that since 2001, the comprehensive index of the ecological environment subsystem of Tarim River Watershed f(A) and the comprehensive index of the socio-economic subsystem in Tarim River Watershed f (B) have been on the rise in a synchronized manner. Before 2004, f(A) was larger than f(B). After that, f(B) got closer to f(A). This indicates that the socio-economic development in Tarim River Watershed is enhanced, the pressure on ecological environment is intensified, and the restriction on socio-economic development is strengthened.

Due to the large-scale development after the founding of the People's Republic of China in 1949, the ecological environment in Tarim River Watershed has changed dramatically. Unreasonable human activities have done much damage to the ecological environment. As a result, water in the trunk stream keeps declining, the mineralization of water is increased, water in the downstream river cuts off, vegetation decays, desertification expands and the ecological environment deteriorates. At the end of the 20^{th} century, an ecological protection and construction program was launched, and a near-term comprehensive control campaign was kicked off for Tarim River Watershed. Moreover, the climate in Xinjiang got warm and wet, posing a positive impact. Although the improvement was imbalanced, the ecological environment in the watershed started to recover. Particularly, in 2001, the State Council listed the comprehensive control program of Tarim River Watershed into the key national projects in the 10th Five-Year Plan. This checked the ecological deterioration in the watershed. Consequently, the comprehensive ecological environment subsystem index is on the rise in recent years.

Tarim River Watershed covers five prefectures, 42 cities, counties and 56 farms which belong to five divisions of Xinjiang Production and Construction Corps. There are one state-level poverty-stricken prefecture and 15 state-level poverty-stricken counties. The socio-economic foundation in this region is quite weak, the proportion of ethnic minorities is quite high, and the overall quality of population is quite low. This is a less developed region in Xinjiang. In recent years, the government of Xinjiang Uygur Autonomous Region vigorously enhanced economic restructuring and accelerated the conversion of superior resources. As a result, much progress has been made in socio-economic development in the region, the local GDP and financial revenues has been on the rise. The agricultural structure is further optimized. Special forestry and fruit industry and animal husbandry keep growing. Moreover, industrial economy underpinned by mineral exploitation starts to prosper, transport and water conservancy infrastructure is further enhanced. In addition, the poverty relief effort is quite fruitful and all social undertakings are further advanced. Consequently, people's living standards are constantly improved, and the socio-economic subsystem index f(B) starts to increase significantly.

18.3.2.2 Analysis of Evolution Velocity

Changes in V_A and V_B (Fig. 18.3) indicate that the two systems don't change in a synchronized manner. In 2001–2005, V_B was smaller than $V_{A.}$ In 2005, V_A reached the highest level in this period, while V_B was at the lowest level. The steady decline of V_B indicates that the internal stress restriction mechanism of the ecological economic system in the watershed is strengthened, and the socio-economic development is slowed down due to the ecological pressure. However, the improvement of ecological environment is accelerated thanks to gradual socio-economic development. In the whole watershed, this is probably because the central and provincial governments increase the investment in the ecological environment control and management in Tarim River Watershed, and the ecological environment in this area is gradually improved as a result of regulation.

18.3.2.3 Analysis of Ecological Economic System Coupling Degree

According to Fig. 18.3 which illustrates the changes in α – the coupling of ecological economic system in the watershed, and Table 18.2, we can see that the value of α decreased from 64.81° to 52.40° in 2001–2005, experiencing a transition from strong development to coordinated development. In 2001–2003, the value of α remained above 55°, indicating that the development was strong but uncoordinated. In 2004 and 2005, the value was slightly lower than 55°, indicating the narrow transition to virtuous development. From the development trend of coupling, we can see that although the ecological regulation and improvement has been intensified in Tarim River Watershed since 2000, the destruction to the ecological environment caused by large-scale and disorderly exploitation of water and land resources in the watershed over the long run can't be compensated within a short time. Plus, due to the socio-economic development for the poverty relief effort in Southern Xinjiang, the ecological economic system was still under strong development in 2001–2003. But the coupling gradually decreased. In 2004 and 2005, the system began to develop in a coordinated manner.

Over a period of time in the future, in the face of great opportunities brought by China's western development program, the accelerated conversion of superior resources and the construction of a well-off society in an all-round manner in Xinjiang, how to ensure harmonious ecological environment and socio-economic development, keep the ecological economic system under stable and coordinated development in Tarim River Watershed so as to achieve sustainable development has become an urgent issue that demands great attention.

18.4 Conclusion

The coupling of the ecological economic system is in fact a process in which the internal ecological environmental subsystem and socio-economic subsystem interact for common development. Judgment of the coupling of the ecological economic system should reflect the degree of coordinated development between the two subsystems, and more importantly reflect the development level of the two subsystems. Only when the two subsystems are well developed can the coupling between them is coordinated and effective. In this paper, an index system is established to assess the coupling of ecological economy, and also an appropriate quantitative assessment model is established to analyze the ecological economic system, the sequential changes between internal subsystems and comprehensive development.

The coupling of the ecological economic system in Tarim River Watershed is relatively low. Although from the perspective of comprehensive indexes, the ecological environmental subsystem and socio-economic subsystem are rising simultaneously, the coupling degree of the ecological economic system in the watershed in 2001–2003 remained above 55°, indicating that the development was strong but uncoordinated, and reached the state of coordinated development in 2004–2005. It can be judged that over a certain period in the future, comprehensive ecological control, conversion of superior resources and construction of a well-off society in an all-round manner in Tarim River Watershed will remain a daunting task, and much needs to be done to facilitate the coordinated development of the ecological economic system and the harmonious co-existence of men and nature.

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Part IV
Value of Ecosystem Services and Ecological Compensation

Chapter 19
Scarcity of Ecosystem Services and Ecological Contribution of Agriculture

Zhu Sihai

Traditionally, the role of agriculture in the process of industrialization can be summarized into four contributions: product contribution, factor contribution, foreign currency contribution and market contribution. Historically, the importance of the four contributions was different at different stages of industrialization. At the initial industrialization stage, the primary tasks of agriculture were to feed non-agricultural population in urban areas, to accumulate funds for industrialization and to provide land and labor for industrial development. At the mid-stage of industrialization, as the proportion of agriculture in GDP and the Engel coefficient kept falling, the reliance of industry on funds and products from agriculture reduced gradually. As the demand of urban residents for industrial products was almost saturated, the countryside became an important market for industrial products, and the market contribution of agriculture increased. In the late stage of industrialization, as a bond for energy exchange between men and nature, agriculture experienced a transformation of its role with an emerging fifth contribution – ecological contribution. At a time when the "deficit financing" of men to nature severely hinders the sustainable development of human society, the focus of agriculture has shifted from purely economic significance to both economic and ecological significance. Consequently, the ecological contribution of agriculture and the importance of its ecological output has become a highlight

Objectively speaking, the ecological function of agriculture is "inherent". It's not until the negative impact of human socio-economic activities on nature exceeds the absorption capacity of nature, the ecology becomes imbalanced, and men's request for the four contributions of agriculture isn't as strong as it used to be when the unique ecological function of agriculture will become increasingly recognized and appreciated by men. As such, the role of agriculture displays a historical return,

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and agriculture itself begins to take on the responsibility of restoring its ecosystem, gradually improving the ecological environment for the survival of men and mitigating the negative impact of industrialization on the ecological environment so that the ecosystem on the earth can form a virtuous circle, and men can survive and develop. This is actually the “regurgitation-feeding” of nature by men through agriculture.

Now, the question is how to fairly divide the ecological responsibilities among people, who should bear the cost of ecological restoration and who should pay the ecological rent for the ecological contribution made by agricultural development. In our study, we will analyze the trend of ecological consumption to explore the scarcity of ecological services and the possible paths for agriculture to meet the demand of men for ecological services.

19.1 Ecological Consumption

In recent years, with the improvement of people’s living standards and the increase in leisure time, consumption activities that involve environmental factors, such as enjoying delicacies, shopping, passing a leisure time, going on vacation, traveling, sightseeing or doing some adventures in places with fresh air and beautiful environment, have become a fashion and an important part of consumer goods. In the past, the environment was a place where literati or people with much spare time to write poems, paint pictures or chant sentimental verses. Nowadays, ecological consumption is quite common in more and more ordinary households and deeply involved in the daily life of ordinary people in various forms as a result of economic development.

19.1.1 Ecological Consumption Is a Spiritual and Cultural Activity

After people’s demand for clothing, food, housing, transport and other daily necessities is satisfied, the demand for comfortable consumption including spiritual and cultural consumption naturally emerges. Consequently, the social consumption fashion shifts from “material consumption” to “ecological consumption”. Here, ecological consumption refers to the consumption of ecological services provided by the environment, or rather the act to purchase, use or enjoy products or services for the purpose of enjoying a comfortable environment (Zhang Junlian 2006). It has mainly 3 forms. First, the consumption does not intend to acquire some tangible commodities (services), but to enable people to have a good time in a pleasing environment where they can cultivate temperament, such as walking in gardens and parks, outing, traveling and taking a beach vacation. Second, when purchasing and using certain products (services), people are more concerned about the overall environment, such as shopping in places with novel decorations, dining in restaurants with a pleasing environment and buying properties in places with a high green coverage rate. Third, the consumption expenditure is used to create, beautify and protect the architectural space environment, such as growing flowers, appreciating bonsai and making sculptures.

Ecological consumption focuses on the satisfaction of people's spiritual and cultural needs. It vividly conveys a delicate emotional appeal and atmosphere through tangible and limited environmental elements so that consumers can recall old memories and feel infinite charms in a limited space. The environment is fraught with dynamic vitality and the scenery is no longer in a fixed physical form that can be easily viewed. Instead, it has profound and fantastic spiritual implications. So it is spiritually significant.

19.1.2 Ecological Consumption Is the Result of Economic Development

A well-developed economy would affect ecological consumption in two aspects. First, the consumption capacity increases as a result of economic development. The increase in consumption capacity reflects the progress of civilization among people. Generally speaking, after their needs for food, clothing, housing and other daily necessities are met, people will begin to pursue cultural entertainment, health, tourism, ecology and luxury. In a well-off society where the problem of food and clothing is solved, people will have a higher requirement for comfort, and they will pursue better living environments and ecological consumption centering on a comfortable environment. Ecological consumption is an important indicator which signifies that people's incomes are increased and they start to pursue well-off consumption. Second, the environmental quality decreases as a result of economic development. As industrialization further deepens and the urban population expands rapidly, people suffering air pollution, noise and traffic congestion will look forward to getting close to nature in places with clean air and quiet environments. Getting close to nature has become an important part of improved quality of life and also an important means to maintain physically and mentally healthy. It doesn't require too much investment. Instead, what you need to do is to remain calm and tranquil. What you earn in return is physical and mental health and improvement of lifestyle which can't be bought by money. As the environmental quality decreases to jeopardize people's quality of life, people are more inclined to a clean, quiet and harmonious natural environment. They are willing to pay to create or improve the environment, and pay for ecological consumption, namely to buy the environment.

A typical example is the readjustment to the urban function zoning by Beijing. Mentougou, Pinggu, Huairou, Miyun and Yanqing are defined as ecological conservation areas which are mainly designed to provide ecological services for the whole city. The principal reason why the functions of suburban and mountainous areas are redefined lies in the contradictions with ecological services provided by the environment. On the one hand, the total demand for ecological consumption rises as people's living standard improves. On the other hand, the supply of ecological services decreases as the economy grows, and the supply of ecological services fails to meet the demand for ecological consumption, leading to the scarcity of ecological services.

19.2 Scarcity of Ecological Services

For a long time, men have used ecological service provided by the environment for free. However, due to economic development, population explosion and unsustainable development patterns, the ecological carrying capacity of the environment has gone beyond the ecological threshold, leading to irreversibility of ecological services provided by the environment. By scarcity of ecological services, we refer to a situation in which the ecological services provided by the environment fails to meet men's ecological consumption demand and the demand for ecological services is greater than the supply because of unsustainable development patterns. The scarcity of ecological services is the fundamental force that drives the transition of agricultural output to ecological contribution.

19.2.1 The Scarcity of Ecological Services Is Increasing

As a result of economic development, ecological consumption is now something common. The boom of holiday tourism, rural household tourism, hiking and mountain climbing, tourism in national forest parks, tourism agriculture and the expanding mineral water market in recent years are evidences that people's demand for ecological services is growing rapidly and that ecological services have become scarce resources. By scarcity growth of ecological services, we refer to the trend in which the scarcity of ecological services rises simultaneously with economic growth. There are four major reasons behind this simultaneous growth.

19.2.1.1 Scale Effect

The scarcity growth of ecological services first stems from the expanding scale of economy. Modern economic expansion is mainly characterized by industrialization. With the evolution of industrialization, the negative impact of economic growth on the environment is quite obvious. First, it comes from the exploitation of resources. When the economy of a country shifts from farming to industry, more and more resources are exploited, which in turn causes a destructive impact on the environment. Second, it comes from the wastes generated in the process of economic development. The rise in output means an increase in wastes, and the expansion of economy is in direct proportion to the increase in wastes. This gives rise to the scale effect of the scarcity of ecological services which grows simultaneously with economic expansion.

19.2.1.2 Demographic Factor

Population is another reason behind the Scarcity growth of ecological services. First, it comes from the pressure of expanding population and from the crowding effect in the living space caused by population pressure. “The pressure effect caused by many people to the environment may have the same consequence as the waste of resources by a few people; even in the primitive society which adopted tribal public ownership, when the population pressure exceeded the environmental carrying capacity, the land productivity would also degrade”.[1] Second, it comes from the improvement of the per capita welfare which is triggered by the expanding scale of economy. According to statistics, among the increase in global energy consumption in 1960–1984, 46 % came from population increase, and 54 % from the improvement of living standards.[2]

19.2.1.3 Consumption Inclination

As a form of ecological consumption, the market size of ecological services is closely related to the level of economic development. In the early stage of economic development, due to the low level of income, people were more concerned about how to get rid of poverty and attain rapid economic growth. Moreover, as the environmental pollution was relatively slight and people’s demand for economic services was small, economic services were luxury for them. As the scale of economy expanded, and the industrial structure changed, people’s consumption also changed accordingly. Consequently, the demand for ecological services increased and ecological services gradually became normal goods. On top of that, the environment degraded as a result of economic development, the supply of ecological services decreased, the market size expanded and the effective supply shrank. Therefore, ecological services became scarce.

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19.2.1.4 Institutional Factor

Ecological services are closely related to economic development. The scarcity of ecological services results from the failure to effectively allocate environmental and natural resources due to the decision-making mechanism in economic processes and the operation of various social and political forces in economic processes. As market and government are two primary means that intervene with resource allocation, the failure of market and the failure of government constitute the major institutional reasons for the scarcity of ecological resources.

19.2.2 Management of Ecological Services

The universality of ecological consumption and the irreversibility of the scarcity growth of ecological services call for management of ecological services, including supply management and demand management. As ecological services provided by the environment constitute a "service portfolio" that involve public goods (such as life support system) and private goods (such as organic agricultural goods), the service providers of ecological consumption naturally include the government and the market. In addition, as the supply of ecological services is now quite insufficient, the demand should be managed to facilitate the balance between the supply and demand.

19.2.2.1 Governmental Supply

Ecological services need to be provided by the government because the property rights of some ecological services are hard to define, cost too much to define or such services are of public nature. For instance, water conservation by the environment, carbon fixation and oxygen generation, pollutant absorption and air purification by the environment are all public goods. Unlike private goods that can be traded in market, have market prices and market values, public goods can't be traded in market, nor do they have market prices or market values. Consumers generally are unwilling to pay for public goods so that others can consume them. Therefore, public goods can hardly enter the market, and should be provided by the government.

Currently, the payment for the cost of ecological services by the government is still the major pattern of ecological services (Scherr et al. 2004). For instance, the U.S. adopted the Conservation Reserve Program (CRP). From 1985 to 2002, a total of 13.60 million hm^2 of farmland was removed from agricultural production, of which 60 % was turned into grassland, 16 % into forest and 5 % into wetland. The program involved 0.37 million farmers and the U.S. government paid US$ 1.5 billion for conservation compensation each year (Heimlich 2002). To cope with the decreasing supply of ecological services, the Chinese government has also taken a series of measures. First, it established many natural reserves. In the past 27 years, the number of natural reserves in China has risen from 34 in 1979 to 2349 in 2006. The size of these reserves now aggravates to 1.5 million km^2, making up 15 % of the country's territory. This is higher than the proportion of farmland which stood at 12.7 %. Second, it launched several ecological restoration programs, mostly ecological construction programs targeting at specific ecological problems, including the Natural Forest Protection Program to address the serious water loss, soil erosion, silting-up of rivers and lakes caused by the lumbering in the middle and upstream regions of the Yangtze River and the Yellow River (with the investment expected to be RMB 96.2 billion in 2000–2010), the Grain for Green Program to address the water loss and soil erosion in sloping farmland in western China (with the investment expected to be RMB 337.0 billion in 2001–2010), and the Beijing-Tianjin Sand Source Control Program to address the sandstorms in Beijing and Tianjin (with the investment expected to be RMB 55.6 billion in 2001–2010).

Because the government supply of ecological services is often oriented to multiple targets, once the prioritized target is shifted, the supply of ecological services will be affected. Take the Grain for Green Program as an example. In 2004, the target for the Grain for Green Program dropped dramatically from 50 million *mu* in 2003 to 10 million *mu* in 2004. This was related to the fact that the restoration of farmland into forest resulted in an increasing shortage of grain output. In fact, the Grain for Green Program had other policy targets from the very beginning, such as addressing the grain inventory pressure caused by the successive years of bumper harvests in 1995–1998, the stagnation of farmers' income due to low grain prices and the huge losses caused by the little effect of reforming state-owned foodstuff enterprises.[3] Therefore, the supply of ecological services is insufficient to meet the ever-growing demand. One of the solutions is to give full play to the market role.

19.2.2.2 Market Supply

It is mainly oriented to the ecological services whose value can be realized directly or indirectly by market. It has two key points. First, the definition of property rights. The prerequisites for the market mechanism to work normally are specifically defined, dedicated, transferrable and practical property rights that cover all resources, products and services. If the property rights are not well defined, specific or secure, people will be discouraged to invest in, preserve and manage resources. For instance, if the property rights of forests are not well defined, it may trigger the short-term behavior of farmers to overuse resources, which in turn will affect the

[3] Tao Ran, Xu Zhigang, Xu Jintao, 2004, Grain for Green Program, Grain Policy and Sustainable Development., The Universities Service Centre for China Studies of The Chinese University of Hong Kong: http://www.usc.cuhk.edu.hk/wkgb.asp.

ecological services provided by the environment. Second, the market construction. As a result of scarcity growth, ecological services need to be compensable and tradable. But market is the prerequisite for this. Worse still, markets of many ecological services have yet to be developed or do not exist at all and the price of ecological services is zero. Therefore, these services may be overused and become increasingly scarce. For instance, groundwater and irrigation water that is priceless in some areas of China is wasted in large quantities.

19.2.2.3 Management of Demand

The management of demand for ecological services refers to the ecological management activities that adopt effective incentives to guide the ecological service consumers to change their consumption patterns, to contain the high consumption of ecological services and the disorderly expansion of demand so as to make ecological services sustainable. Ecological consumption is a type of universal consumption. The management of demand for ecological services is an important measure to mitigate the scarcity and increase the efficiency of ecological services. It is of great significance to facilitating the harmonious development between men and nature.

Currently, the ecological environment in China is quite vulnerable. According to the *Nature and Ecology Conservation in China* published by the State Environmental Protection Administration on June 4, 2006, the total size of ecologically vulnerable areas makes up over 60 % of the whole territory, the per capita reserve of resources is less than a half of the world's average, but the energy and material consumption per unit GDP is higher than the world's average. These pose a daunting pressure to ecological environment. Moreover, due to the relative shortage of per capita reserve of resources and the insufficient investment in ecological protection, the deterioration of ecological environment is not effectively contained. While the demand for ecological services keeps growing at a fast pace, the reserve of environmental resources available for exploitation is inadequate, causing many potential problems. National conditions, experiences and lessons reveal that the traditional development pattern which purely relies on the increasing supply to meet the growing demand can no longer meet the requirement of coordinated development between men and nature. So when enhancing environmental protection and increasing the supply of ecological services, we must put the management of demand for ecological services on par with the management of supply, plan the resources of suppliers and consumers in a comprehensive manner and optimize the allocation of ecological service resources so as to promote the harmonious development between economy and society, and between men and nature.

19.3 Ecological Services of Agriculture

Obviously, to address the scarcity growth of ecological services in the process of economic development, a policy of "walking on two legs" needs to be adopted. On the one hand, we need to guide consumers to consume ecological services moderately. On the other hand, we need to blaze new trails to the supply of ecological services. The core of the so-called ecological contribution of agriculture is to expand the service areas of agriculture so as to provide ecological services for men. Specifically, agriculture can provide 5 types of ecological services.

19.3.1 Green Service

The primary function of agriculture is provide green agricultural products, including clean agricultural production for less environmental impact and green good and other non-food agricultural products. The traditional agricultural production pattern itself causes pollution and damages to the environment, including water loss, soil erosion and degradation (salinization, desertification and decline of fertility) due to unreasonable land utilization, food pollution, ecological destruction and loss of biodiversity as a result of improper use of fertilizer and pesticides. The fundamental objective of clean agricultural production is to effectively control the pollution and damages caused by agriculture to the environment and to provide pollution-free, safe and green agricultural products so as to meet people's demand for ecological services from agriculture.

19.3.2 Environmental Capacity

The environmental capacity, also known as the environmental carrying capacity, refers to the environment's natural purification ability after it absorbs pollutants. From the perspective of men, it refers to the quantity and density limit to which pollutants from men can be absorbed by the environment. The environmental capacity is the self-regulating capacity of the environment. The capacity of water bodies to degrade certain pollutants, the capacity of the atmosphere to dilute certain pollutants and the capacity of trees to regenerate that are familiar to us are all part of this self-regulating capacity. The environmental capacity is a resource that is recoverable and renewable within a certain ecological threshold. The process of agricultural production, particularly the production of green plant products, has the ability to recover or renew environmental resources itself. It is an important foundation to increase the purification capacity of the environment, and also the core force to restore, improve and increase the environmental capacity.

From the perspective of urban-rural relations, ecological services provided by the countryside constitute the "ecological infrastructure" of urban areas, and the fundamental guarantee for urban areas and residents to continuously receive ecological services, including fresh air, green food, ecological shelter and leisure recreation.

19.3.3 Energy Service

Energy service refers to the solar energy (biomass energy) obtained by plants through photosynthesis. The development of biological energy includes 2 aspects. First, energy substitution, such as the substitution of biogas for natural gas, and the substitution of plant oil for diesel oil (i.e. biological diesel oil). Second, energy conversion, such as the production of ethanol from corn through biological fermentation, and further the production of ethanol gasoline (i.e. gasohol). Practices from around the world have indicated that biogas and gasohol are the highlights of energy agriculture.

Biogas is a combustible gas, mainly methane, which results from the microbial fermentation of organic matter under anaerobic conditions. It is the key to energy substitution in rural areas. The conversion of dung of men, livestock and poultry, straws, organic agricultural residues, organic waste water from processing agricultural and sideline products, industrial waste water, urban sewage and garbage, aquatic plants and algae into biogas through fermentation is an effective way to generate energy from biomass. It can provide energy and dispose of organic waste, thus contributing to agricultural ecological construction and environmental protection. Therefore, it is an important part of agricultural ecological services.

Gasohol refers to the mixed fuel after a certain proportion of denatured alcohol is added to gasoline. It is a clean and practical fuel. In 1975, Brazil launched the world's first gasohol program to make fuel alcohol from sugarcane. Currently, it produces 10 million tons of alcohol every year, 97 % of which is used as vehicle fuel. Alcohol is mainly produced through the biological fermentation process, in which plant materials are used, including starch bearing materials, molasses and fibers. A wide variety of crops can be used, including corn, sorghum, sugarcane, sugar beet, potato, sweet potato and cassava. They are all high-yield crops that can ensure food security and serve as good energy crops.

Energy agriculture is an important sector that comprehensively utilizes agricultural resources to mitigate energy shortage, protect the ecological environment and increase the overall benefit of agriculture. It is also a new economic growth source for agricultural economical services.

19.3.4 Amenity Service

The agricultural ecosystem is a very good living resource (Jiaen and Weimin 2004)[(4)]. Agriculture can provide sightseeing, leisure and entertainment services for people to meet their need to return to nature, enjoy pastoral sceneries and delight their moods. In addition, agriculture can provide cultural and educational functions. Over its long development history, agriculture has accumulated a rich wealth of cultural connotations. The natural growth rules of crops, evolution of agricultural production patterns, farming practices and rural customs are part of culture, and indispensable for men to correctly understand nature. Particularly, for people that live in urban areas and cannot tell wheat from beans, it is more important to intensify the education and propagation of agricultural knowledge.

With regard to the demand for ecological services, urban areas need the ecological services provided by rural areas. The more urban areas develop, the more precious the ecological services provided by forests, water systems, fields and villages will become. In particular, the suburban countryside has become a "spiritual home" for many urban residents where they can seek recreation and entertainment, pursue physical and mental improvement and experience a rural life.

19.3.5 Ecological Trade

Practically, this refers to the transfer of ecological conditions in the trading process of agricultural products, and a special manifestation of agricultural ecological services. Specifically, ecological trade mainly provides three forms of agricultural ecological services. First, the transfer of water resources, with virtual water trade as the core.[4] The trade of water-intensive agricultural products will necessarily bring about the transfer of virtual water to trigger the import or conservation of water resources. This is of special significance to protect the agricultural ecosystem in areas where water resources are scarce. Second, the transfer of land resources. Due to low per capita farmland acreage, and the progress of industrialization and urbanization, the net decrease of farmland has become an irreversible trend in China. The conservation of farmland resources through the trade of agricultural products naturally becomes a viable option. The transfer of land resources in ecological trade is of great significance to land-intensive agricultural products. Third, the transfer of environmental quality. Because chemical fertilizers and pesticides are still used in agricultural production, the improper use of them and the ever-increasing usage of them per unit area of farmland constitute the primary causes for decreasing organic matter in soil, declining biodiversity, food safety and other ecological and environmental problems. Consequently, the transfer of environmental quality is obvious in ecological trade.

[4] Virtual water is also known as embedded water or exogenous water. The concepts of virtual water and trading of virtual water were coined by Professor T. Allen of University of London in 1993. The amount of water resources consumed for the production of a commodity or service is known as the virtual water contained in the commodity or service. The transfer of virtual water brought by the import and export of water-intensive products is called the trading of virtual water. The two concepts provide new perspectives for studying the relations between the trade of agricultural products and the transfer of water resources.

In essence, the trade of agricultural ecological services constitutes the global redistribution of ecological services, which is of special significance to the balance of ecological burden between developed and developing countries.

19.4 Value Realization of Agricultural Ecological Services

With regard to the five types of ecological services, an issue needs to be further clarified, namely how to realize their values? In other words, how to establish value contacts between the providers and consumers of ecological services? This involves three aspects. First, the nature of services, i.e. whether the services are public goods or private goods. If the services are public goods that are independently provided by the government, and used by consumers free of charge, there is no need to establish value contacts between suppliers and consumers. Otherwise, we need to carefully consider how to realize the values of ecological services. Second, the market, such as whether the property rights are clearly defined, whether the market exists, whether the competition is adequate and whether externalities can be internalized. Evidently, services that are not safe and services whose property rights don't exist or can hardly be defined can't access the market. Similarly, if the market doesn't exist, the foundation upon which ecological services are provided as private goods will be lost. But the market that is monopolized will affect the demand for ecological services. Third, the government. It provides market infrastructure for the ecological services provided by private people, and offers ecological compensation for ecological services with positive externalities. The value of agricultural ecological services is realized by focusing on the aforementioned three aspects. They can be addressed in the following two ways.

19.4.1 Ecological Compensation

Ecological compensation[5] is one of the main approaches to realize the value of ecological agricultural services, which is mainly embodied in the following three cases.

[5] Currently, there is no standard definition for the connotation and denotation of "ecological compensation" in the academic community. This paper argues that, as the environment has the value of resources and the value of ecological services, the broader sense of "ecological compensation" should include the compensation for stakeholders for exploiting the value of resources, and the compensation for stakeholders for improving the quality of ecological services and taking environmental protection measures. The former is also known as the compensation for the value of resources, such as the water resource fee for the exploitation of water resources and the charge for industrial pollution. The latter is also known as the compensation for the value of ecological services, such as the compensation for returning farmland into forests and the compensation for ecological immigration. In our study, the compensation for the value of ecological services is used.

19.4.1.1 Ecological Services Are Provided by the Government But They Infringe Upon Private Interests

This mainly involves the supply of ecological services as public goods. There are two scenarios. First, people don't participate in the supply of public goods, such as the financial compensation for ecological immigrants displaced for the construction of natural reserves. Second, public goods are provided by the government with the participation of people, such as the ecological compensation provided by the government for rangers of ecological forests in mountainous areas so as to enhance the ecological conservation function of the suburban areas in Beijing (There are nearly 40,000 people on the payroll. The per capita compensation is RMB 400 per month. A total of 9.12 million *mu* of ecological forests are covered in the program).

19.4.1.2 Ecological Services Are Provided Privately But Can't Access the Market

The reason why ecological services can't access the market might be that there is no market, or that these services are not allowed to access the market. For instance, for non-commercial forest operators or owners, currently there is no forest carbon trade market in China, but lumber has limited access to the market. Therefore, the public finance needs to provide compensation for forest ecological benefits. A pilot program was launched in 2001. The central government earmarks RMB 1 billion every year for 200 million *mu* of non-commercial forests that offer ecological benefits for forest farms and natural reserves. In 2003, the Ministry of Finance allocated RMB 90 million to compensate private investors that build non-commercial forests.

19.4.1.3 Ecological Services Are Provided Privately, Can Access the Market But Have Some Externalities

This mainly concerns ecological services between upstream and downstream regions, particularly the trade of water resources, such as the trade of water rights between Dongyang and Yiwu of Zhejiang Province as an example. It is calculated that the marginal cost of water resources is RMB 1/m^3 and RMB 6/m^3 respectively in Dongyang and Yiwu. After multiple rounds of talks, the two parties reached a deal, under which Dongyang will permanently transfer the use rights of 50 million m^3 of water in Hengjin Reservoir to Yiwu for RMB 4/m^3 as a means to internalize the externalities.

19.4.2 Market Trade

To realize the value of ecological services through market is the development trend of agricultural ecological services. The key is to create an ecological service market and lower the transaction costs. Landell-Mills et al. (2002) studied 287 ecological service transactions around the world, and found that small transactions are more likely to succeed due to clear transaction subjects, small quantity and low transaction costs. When the transaction is very large, the transaction cost may increase dramatically prevent the transaction from taking place at all. To create an ecological service market, the government needs to build the "market infrastructure", put in place a market transaction platform (market system and transaction institutions), and provide market cultivation, technical support and financial management as well as measurement, accreditation and monitoring services. In some developed countries, in order to build a market for ecological services, the government has created some quality indexes for surface water, salinity indexes for groundwater and SO_2 emissions indexes for air quality (Tognetti 2001). Developing countries have created a trade market (forest carbon sink market) to offset greenhouse gas emissions through carbon fixation by forest. According to international experience, the value of agricultural ecological services is mainly realized in market around three aspects.

19.4.2.1 Ecological Labeling

Ecological labeling is a type of product certification. For agricultural products, ecological labeling is mainly used to tell consumers whether the production is environmentally healthy so as to solve the information asymmetry on environmental quality of products between producers and consumers. As agricultural products that are produced in an environmentally friendly way can sell at higher prices in market, ecological labeling is in fact a type of direct payment for ecological services under which consumers pay for the values of ecological services of products by means of certified ecological labeling. Therefore, the ecological labeling system constitutes an important instrument to realize the values of agricultural ecological services and facilitate value increment of agricultural products. The adoption of ecological labeling system can help cultivate a market-oriented ecological service compensation system so that consumers can, through the market chain and by means of purchase, pay for the values of ecological services of certified agricultural products that are produced in a sustainable manner, and eventually promote the value realization of agricultural ecological services in market.

The ecological labeling of agricultural products (food) in China falls into three classes, namely pollution-free agricultural products, green food and organic food, which constitute a pattern of ecological labeling certification based on pollution-free agricultural products, led by green food and supplemented by organic food.

19.4.2.2 Trade of Right to Use Environmental Capacity

The environmental capacity represented by the self-pollutant purification capacity is a resource. The contribution of agriculture to the environmental capacity is quite significant, which is embodied by the restoration, improvement and conservation of self-purification capacity, including the restoration of environment by returning farmland into forests, the improvement of the environment by ecological forests and the conservation of the environment by non-commercial forests. The value of agricultural ecological services is directly represented by the value of environmental capacity resources, and value realization of agricultural ecological services naturally relies on the value realization of environmental capacity resources. The major issue is how to monetize the value of environmental capacity, or rather how to capitalize the environmental capacity resources. The core to this issue is the trade of the right to use environmental capacity in market. Currently, internationally proven practices include emissions trading and forest carbon-sink trading.

Emissions trading was first conceived by John Dales in 1968, and adopted by the U.S. Environmental Protection Agency in 1986. Under this framework, governments set a limit or cap on the amount of a pollutant that may be emitted, and issue emissions permits accordingly. The permits can be traded in market. Thanks to the emissions trading system, it is possible to realize the value of environmental capacity resources created by environmental protection in market. Environmental protection, in essence, is an investment made by men in nature, and the typical output is the environmental capacity. Economically, the environmental capacity created by environmental protection is a type of conservation of pollution emissions. Under the precondition of total amount control, such conservation provides a viable channel of supply for enterprises or individuals that need to emit pollutants, and space to realize the value of agricultural ecological services in market.

Forest carbon-sink refers to the function of forest plants to absorb and store CO_2 in their growth process. Forest carbon trade is associated with the *Kyoto Protocol*. Effective worldwide from February 16, 2015, the protocol is the first of its kind in human history to cap greenhouse gas emission through legislation. It consists of the emissions reduction program and the carbon sink program. The emissions reduction program is mainly designed to reduce the greenhouse gas emission by improving energy efficiency and using alternative or renewable energy. The carbon sink program mainly covers the trading of CO_2 emissions which can be traded freely as a type of commodity among all signatory countries. Also, carbon sequestration under the Clean Development Mechanism (CDM) is the only mechanism for cooperation on forestry between developing and developed countries under the framework of *the Kyoto Protocol*. It is mainly designed to offset the CO_2 emissions reduction obligations of developed countries through forest carbon sequestration. It is an important approach to compensate the values of ecological services of forests through market mechanisms. The first international carbon sequestration project in China was launched in 2005 at Aohan Banner of Inner Mongolia Autonomous Region in northern China. Using US$1.35 million funds from the Italian Ministry of

Environment and Land Resources and US$ 0.18 million from China, the project would plant 3000 hm^2 of trees in the desert of Aohan Banner. By 2012, Italy can claim carbon emissions credit for the project to meet its CO_2 emissions reduction commitment. As a special approach to realize the values of ecological services, forest carbon trade adopts a market mechanism. It can help China's forest sector attract foreign funds and advance the marketization and monetization of forest ecological services.

19.4.2.3 Agricultural Eco-Tourism

Agricultural eco-tourism, also known as sightseeing agriculture, recreational agriculture, eco-agricultural tourism and tourism agriculture, is a new agricultural and tourism mode based on agricultural resources, which leverages rural landscape, agricultural production activities and unique rural cultural scenery to attract tourists to view, recreate, exercise, shop and spend holidays, and meet their demands for food, accommodation, travel, shopping and recreation. From the perspective of consumers, agricultural eco-tourism falls into two categories, namely amenity services and experience services.

Eco-tourism that mainly provides amenity services includes:

1. Agricultural sightseeing gardens, mostly picking gardens, such as orchards, vegetable gardens, flower gardens and tea gardens where tourists can pick fruits, vegetables, flowers and tea for pastoral pleasure.
2. Recreational gardens, such as rural home inns and fishing gardens where tourists can enjoy the scenery and pick fruits in the gardens, learn about farmers' life, enjoy rural pleasure, live in the gardens, spend holidays and take part in recreational activities.
3. Forest gardens, including various types of forest gardens and scenic spots which are ideal sites for people to return to nature, spend holidays, camp, avoid summer heat, carry out scientific research and enjoy forest bathing.
4. Agricultural theme parks, such as the vineyards in Japan which integrates the scenic views, picking and taste of grape products (including wine, grape juice and grape ice cream) as well as the processing and taste of grape products, writing, painting, photography, experience, contests and anniversary celebrations. They provide economic, ecological, public welfare and social functions to attract tourists and make considerable profits.

Eco-tourism that mainly provides experience services includes:

1. Urban farming gardens. Farmers rent their land to urban residents so that they will buy seedlings, fertilize the soil, grow vegetables, water them, experience farmland management, take part in agricultural technology exhibitions to appraise the harvested agricultural products, make food with the vegetables and fruits they grow and share them with others. In addition to picking, selling, viewing, fishing and entertainment activities, the labor process can also provide

an opportunity for urban residents to take part and experience. It is an unconventional way for agricultural development, which plays a very important role in developing and utilizing agricultural resources in a comprehensive manner, improving urban-rural relations and meeting the demand of urban residents for returning to nature and recreation.

2. Special agricultural gardens, such as the ecological education gardens and agricultural propagation gardens for primary and secondary students where they can review the scientific knowledge they learn in class, put the knowledge into practice and increase their farming knowledge.

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Chapter 20
Participation of Natural Resources in Income Distribution – A Distribution System Balancing Intergenerational Equity and Ecological Efficiency

Luo Liyan

The participation of natural resources in income distribution requires the backup of appropriate value theories and distribution systems. This paper will, from these two aspects, expound on the theoretical foundation for natural resources to participate in income distribution and the practical significance of this participation. It will also demonstrate that the theory of distribution by contribution of factors, which is based on the dualistic value theory, is a reasonable distribution system that balances intergenerational equity and ecological efficiency.

20.1 Theoretical Foundation for Natural Resources to Participate in Income Distribution

The unity between value creation and value distribution has been frequently studied and discussed across the academic community. However, no consensus has been reached yet. We believe that the value theory is the theoretical foundation of the distribution system, and that value creation and value distribution should be unified. The theoretical precondition for natural resources to participate in distribution is the acknowledgement of the value of natural resources. There are many academic works on the value of natural resources. They are mainly based on the labor theory of value by Karl Marx, the utility theory of value in western economics and the theory of equilibrium price, or a combination of several value theories to demonstrate the value of natural resources. There are also some explanations from the perspectives of philosophy, biology, and physics (energy). Although these

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discussions confirm the value of natural resources and expound on it to some extent, they are somewhat biased, far-fetched or unconvincing due to the lack of economic perspective. Then how shall we understand the value of natural resources?

20.1.1 Dualistic Value Theory Which Argues That Value Is Co-created by Men and Nature

Value in the economic sense is a historical category formed in the process of production, embodied and measured in the process of exchange, and realized in the process of distribution and consumption. Without the exchange process, and without the commodity economy, there would be no "value" in the economic sense. The basic idea of dualist value theory is inspired by the review of production factors. A historical and logic analytical method is employed to integrate the realistic production system into a historical process for review, and whether each production factor can be substituted is used as the criterion to separate two most fundamental production factors from all the production factors: human labor and natural resources, or more commonly known as human force and natural force. Corresponding to the fundamental production factors, all the other production factors are called derivative factors, which can be converted from the two fundamental factors. For instance, tools are manufactured from materials provided by nature. Machines and equipment, no matter how sophisticated they are, originate from the simplest production process. Management and technologies are derived from the brainwork of men. The categorization of production factors is a prerequisite for exploring the source of value. Only when the superficial phenomena are removed layer from layer, all uncertainties are eliminated and all possible interferences are ruled out can we discover the nature of value. Therefore, to identify the mutually accepted "value" in the exchange relations, we must return to the simplest and most primitive exchange relations

The human force and natural force are respectively noted as H (Human resource) and N (Natural resource). Products are exchanged between men and the value in the economic sense is embodied in the process of exchange. If Producer A (H_A) makes Product A (P_A) from natural resources and Producer B (H_B) makes Product B (P_B) from natural resources, we have an equation as follows:

$$H_A + N \rightarrow P_A \qquad \text{HA}$$
$$H_B + N \rightarrow P_B$$

When Producer A and Producer B agree to exchange their products, we have an equation as follows:

$$P_A = P_B \tag{20.1}$$

or:

$$H_A + N = H_B + N \tag{20.2}$$

In Eq. (20.2), the quantity, quality and type of N (natural resources) at both ends of the equation can be different. But as long as the natural resources are commonly owned, abundant and can be used by each person for free, the amount of N will not affect the result. At this time, what both parties of the exchange, acknowledging what the other party offers is useful for themselves, are willing to pay is only the labor spent on commodities, because the consumption of labor, including the consumption of physical and mental work need to be compensated through exchange. This is the value monism which argues that the value is created by labor. But when natural resources are not commonly owned or inexhaustible, in the long run, to keep social production running and maintain the sustainable development of human society, the depletion of natural resources needs to be compensated, and the exchange value should include the value arising from the depletion of natural resources. In this case, like human labor, natural resources are also the source of value. This is the basic idea of dualistic value theory which argues that value is co-created by men and nature.

20.1.2 Source of Value and Factor Contribution

Although the dualistic value theory acknowledges that the two fundamental production factors are sources of value, it doesn't deny the production contribution of other derivative factors. From the analysis approach of dualistic value theory, we can clearly see that the production contribution of fundamental factors can be compounded into the production contribution of derivative factors, and the production contribution of derivative factors can be broken into the production contribution of fundamental factors. For instance, a fisherman catches fish with bare hands in a pond. This production activity constitutes a productivity system made up of two fundamental factors. Surely, the production efficiency is quite low. To increase the efficiency, the fisherman plants hemp to make a fishing net, and then uses the fishing net to catch fish. So the production efficiency is increased. At this time, the productivity system consists of three factors: the fisherman (labor), fishing net (tool or capital) and fish (natural resource). The fishing net is made up of the contribution of two fundamental factors, namely weaving and hemp, or rather the production contribution of the fishing net can be broken into the labor contribution of weaving and the material contribution provided by hemp. For such a simple production activity, we can easily reduce the non-fundamental factors, namely derivative factors, into two fundamental factors. But for modern mass industrial or high-tech production activities, such reduction approach would be quite sophisticated. When measuring the production contribution, it is not necessary to reduce each production process like this. The simplest method is to directly measure the production contribution of the factor. In this way, we can migrate from the dualistic value theory to the theory of contribution by factors.

The internal relations between the dualistic value theory and the theory of contribution by factors can be proved using the approach of roundabout production. In modern economic activities, it is hard to find a productivity system which has only two fundamental factors. Most production activities are roundabout ones. That is, they make tools and machines before starting production, and these activities are carried out separately. Machines and equipment are introduced into production as a relatively independent production factor to help save labor, lower labor intensity and reduce resource depletion. Without this, people would rather produce directly to spare the trouble of making tools or machines. Therefore, we can conclude that derivative factors always reduce the depletion of fundamental factors so as to lower the production cost or increase the output at the same cost. Although from the perspective of value theory, fundamental factors and derivative factors play different roles in forming the value, they eventually contribute to the production of final products.

In fact, the dualistic value theory itself defines a corresponding distribution system: necessary depletion in production must be compensated or substituted in distribution, giving rise to the origin relationship between value theories and distribution systems. But we must admit that value theories and distribution systems are issues at two different levels. The trace of value source in value theories needs an abstract logical analytics method to remove the superficial phenomena to find the essence of value. In contrast, distribution is only an issue of practical operation and can't abstract away the contribution of a factor. A reasonable distribution system can neither exclude the subject of value creation – human labor and natural resources from the distribution, nor deny the contribution of derivative factors that play an indirect role in value creation. Therefore, the distribution by contribution of factors provides a practical and a reasonable institutional option.

Then how shall we tell whether a factor can contribute to production in a productivity system consisting of multiple factors? The answer is that we can tell whether the factor can be substituted in the production process. There are two substitution methods. The first is heterogeneous substitution, namely the factor is substituted by another type of factor, such as the substitution of labor for capital. The second is homogeneous substitution, for instance some labor is substituted by other labor. To explore the sources of value, a historical analysis of the productivity system consisting of factors is made. That is to say, all the existing factors are reviewed across a long period of time in human development history. The conclusion is that human labor and natural resources are two most fundamental production factors that can't be substituted. Therefore, it can be concluded that men and nature are production factors that can contribute to production under any circumstances. A brief review of a realistic productivity system consisting of factors will reveal that, on condition of adequate market competition, complete information and free flow of factors, the substitution, whatever type it may be, will take place until a most efficient combination of optimal factors is formed as long as the substitution can reduce the production cost. This optimal combination not only includes fundamental factors, but also derivative factors. According to the principle of efficiency first, the role of these factors is irreplaceable. Therefore, they are all contributive to production and are entitled to participate in distribution.

20.2 Distribution by Contribution of Factors Based on Dualistic Value Theory

20.2.1 Distribution At the Compensation Level

By decomposing the currently conventional productivity system consisting of factors, i.e. the combination of optimal labor, natural resources, capital and management, we can reveal the two levels of distribution. For the sake of convenience, these production factors can be personated. Suppose they are all their own masters, and they will undergo different levels of depletion in the production process to attain the expected production purposes. After a production cycle is completed, to ensure the continuation of the next production cycle, these factors need to be compensated for their own depletion. If a factor is completely run out, a new substitute will be required. Therefore, one of the most fundamental objectives of distribution is to provide adequate compensation for the depletion of all production factors. It is the prerequisite for maintaining simple reproduction, and also the first level of distribution: distribution at the compensation level.

In the distribution at the compensation level, laborers demand necessary wages to sustain life and raise offspring; capital goods demand the compensation of depreciation incurred in the process of production; natural resources are entitled to compensation for renewal or substitution; managers desire both the payment of subsistence wages, but also the recovery of their human capital investment that is amortized over the current period, which can be called the compensation of human capital (suppose that the subsistence wages of laborers include the compensation for basic human capital). As a result, we can get an equation for the distribution at the compensation level: labor – subsistence wages, capital goods – depreciation, natural resources – compensation, managers – subsistence wages + compensation of human capital.

20.2.2 Distribution At the Surplus Level

Any realistic production activity has an economic surplus where the output is higher than the input. Economic surplus mainly comes from three channels: the free supply of natural forces, the intensive exploitation of natural forces by human intelligence, and the systematic effect from the synergy between production factors.[1] Existence of economic surplus has decided that after the distribution at the compensation level is satisfied during the distribution process there are surpluses that have to be divided among the production factors. This leads to a second level of distribution, namely, distribution at the surplus level.

The economic surplus should be distributed according to the contribution of all production factors. Technically, it is difficult to measure the contribution of these factors, because the coupling and mutual assistance among all factors of a productivity system is crucial, and it is almost impossible to accurately separate the contribution of a single factor. But the market mechanism can help solve this problem. The importance and contribution of a factor to a specific productivity system can be measured using the substitutability of the factor. If a factor is the scarcer; it cannot be substituted heterogeneously and it is impossible to even find a homogeneous substitute for it, then this factor is dominant in the productivity system and can be called the dominant factor. Normally, the dominant factor can share more economic surplus. For instance, a patented technology or an outstanding manager can be a dominant factor, because it is hard to find a substitute for them. In contrast, an ordinary physical laborer can be substituted by thousands of laborers in the market where the supply of labor is excessive, so he can never be a dominant factor. The inter-factor substitution is accomplished through the market mechanism. The contribution of all factors to production can ultimately be confirmed by market. In a market-oriented economy, the regulation of supply and demand is an objective power that complies with laws.

The relative scarcity of production factors doesn't remain unchanged, so dominant factors vary in different stages of economic development. In the age of agricultural economy, social wealth mainly comes from agricultural production, so the ownership of land would ensure an initiative in agricultural production. Land, particularly, fertile land is a scare production factor. Land owners can enjoy more economic surplus in the distribution. In the era of industrial economy, manufacturing constitutes the main force in wealth creation. The organization of large-scale industrial production requires prepaid capital. Otherwise, the industrial production can't be carried out. As a result, capital becomes the dominant factor, and owners of capital can enjoy more economic surplus. In knowledge economy, the contribution of information and knowledge to social wealth becomes paramount, and capital is no longer a factor that constrains production. Therefore, knowledge (technology) becomes the dominant factor. People in possession of high-tech knowledge will enjoy more economic surplus. (What's the difference between dominance and scarcity?)

[1] For detailed analysis of source of economic surplus, refer to Analysis of Economic Surplus Source by Luo Liyan and Li Xiaolong, Contemporary Finance & Economics, 2004.3, 5–9.

20.3 Analysis of System of Distribution by Contribution of Factors in Western Economics

The above analysis is under the premise of personation, i.e. each factor has an independent personality or independent ownerships. In reality, factors and factor owners represent two different categories. For laborers and managers, they are both production factors and owners of their own labor and management expertise. That is to say, human factors and human capital ownerships are concentrated on the same subject – men (except in the case of slavery), and they are unified. For capital goods and natural resources, they are things and can only be owned by men. So the factors and factor owners are separated. In the distribution formula proposed by Jean-Baptiste Say and Alfred Marshall, it seems that distribution is based on the contribution of factors, but in fact it is based on factor ownership. Analysis of the factor distribution result as per the quaternity distribution formula at the two distribution levels will reveal that under this distribution system, natural resources are missing at the first level of distribution, namely distribution at the compensation level.

According to the quaternity distribution formula, factor owners participate in the distribution on behalf of all factors. Laborers that provide labor receive wages, land owners that provide land receive rents, capitalists that provide capital receive interests, and business owners that provide management expertise receive profits. By dividing these factor incomes at two levels, we can find that distribution of these four factor incomes is different at the two levels. For laborers and business owners, factors and factor owners are united, so their shares in the distribution contain two levels, namely subsistence wages and economic surplus distributed according to contribution. Even if they don’t share the economic surplus, they will first use what they receive from distribution to meet the needs of subsistence, i.e. to compensate the physical labor and brainwork depleted in production so as to maintain normal life activities. This is decided by the biological instincts that people will seek subsistence before development. Therefore, it can be concluded that human factors (laborers and managers) participate in the distribution at two levels, and the distribution at the first level is prioritized. For land and capital factors, their shares are owned by land owners and capitalists. As these two factors are separate from their owners – land owners normally don’t work in the land and capitalists don’t directly manage their capital goods – they are not liable to compensate the depletion of factors. They share the economic surplus according to their ownership in the distribution. This is the distribution at the second level. The depletion of capital goods in production, i.e. capital depreciation, is often deducted by operators as cost, and recognized as a special fund to compensate the capital depreciation, including machine maintenance, and factory building repair. This shows that the distribution of capital at the two levels is accomplished respectively. This is also reasonable, since it ensures that the depletion of capital goods is compensated in a timely manner and that the production is carried out smoothly. However, producers in the past tended to rely on the self-compensation of nature for the depletion of land and other natural resources in production, or thought compensation was not necessary. Therefore, operators often failed to deduct the compensation that natural resources deserve as costs (or only deducted a small amount, depending on the types and characteristics of natural resources). That is to say, natural resources did not receive the compensation at the compensation level. The compensation is converted into economic surplus that is shared among factor owners and product consumers.

20.4 Equity and Efficiency When Natural Resources Participate in Distribution

The participation of natural resources in distribution has changed the traditional distribution pattern. Natural resources participate in distribution as a production factor with an independent personality, and take a share of the economic surplus that could have been divided among factor owners according to their contribution as compensation. Inevitably, the shares that can be divided will be reduced, which will have different impacts on the interests of all factor owners. How will this new interest distribution pattern affect social equity and economic development efficiency?

The efficiency involved in distribution is economic efficiency. It is generally believed that the distribution based on contribution of factors helps encourage the production factors to participate so that the economic efficiency is increased and economic growth accelerated. However, due to the natural disparities of social members in terms of abilities and opportunities, a significant income gap will arise even in a fair society, and such gap will foster unfair competition, resulting in a broader income gap and a concentration of wealth in a minority of people that eventually exacerbates social inequity. Therefore, efficiency and equity are thought to constitute a permanent contradiction in distribution. Consequently, to put efficiency first while giving consideration to equity makes an acceptable compromise. To lay stress on efficiency in primary distribution and on equity in secondary distribution has become an income distribution policy widely practiced in market economies.

The theory of distribution based on contribution of factors we have established on the basis of dualistic value theory in our study divides distribution into two levels. The distribution at the compensation level uses the actual depletion of all production factors in the production process as the criterion. Equity is the primary goal of distribution at this level. The distribution at the compensation level is achieved not only through market, but also in many cases through government intervention. For instance, if the factor price completely determined by market supply and demand is taken as the final distribution result, when the supply of labor is in serious surplus, labor wages will be lowered to below the subsistence wages as a result of competition. In this case, the minimum wage law instituted by the government can rectify the inequity caused by excessive market competition.

Efficiency is taken as the criterion for the distribution at the surplus level. It measures the contribution of factors through market and encourages competition. While this helps increase economic efficiency, it easily broadens the income gap. On top of distribution at the compensation level, appropriately broadening the income gap is essential to keeping the economic system active. Obviously, the distribution at the compensation level embodies equity while the distribution at the surplus level pursues efficiency. Organic combination of the distribution at the two levels makes a reasonable distribution system that addresses both equity and efficiency.

The above analysis proves that, in the previous distribution based on contribution of factors, natural resources are missing in the distribution at the compensation level. Next, we will analyze the impact on equity and efficiency after the compensation is distributed to natural resources. First, for natural resources, the degree of equity represents a leap forward from scratch, and it doesn't affect the share of other factors in the distribution at the compensation level. Second, in the past, the compensation that natural resources didn't receive was distributed as economic surplus at the second level. The distribution at the surplus level constitutes the major reason behind broadened income gaps. Ensuring that natural resources receive distribution at the compensation level will reduce the economic surplus, narrow the income gaps resulting from the distribution at the surplus level, and promote equity in income distribution. Third, the participation of natural resources in distribution will have a positive impact on economic efficiency. As the economic surplus available for distribution is reduced, the competition will intensify. This will allow the optimal allocation of resources and increase the efficiency of resource utilization.

This is just a brief cross-section analysis. A long-term time series analysis would prove that the participation of natural resources in distribution is of great importance to achieving intergenerational equity and increasing ecological efficiency. As a concept on equity for sustainability, intergenerational equity pays attention to the equity and fairness between the present and future generations in terms of existence conditions and development opportunities, and focuses on how to realize reasonable allocation of natural resources between different generations. Artificial resources, social resources and technological resources are constantly accumulated in the historical process of human development and can be inherited by future generations. Only natural resources, particularly exhaustible resources, have no choice but become scarcer. People of the present generation shouldn't undermine the existence basis of future generations for their own development. Instead, they should leave enough development room for future generations. To achieve this, natural resources should not only be distributed properly among people of the present generation, and also between the present and future generations. When natural resources don't participate in distribution, the fact that resources are not priced and the prices of resource products are quite low will encourage excessive exploitation and utilization of natural resources. This will undermine the renewability of renewable resources, accelerate the depletion of exhaustible resources, deprive future generations of the right for natural resources, and severely affect the existence of the present generation. On the contrary, the participation of natural resources in distribution can rectify unreasonably low resource prices and control the excessive consumption of resource products. More importantly, the compensation for natural resources is invested in the recovery of renewable resources and the development of substitutes for exhaustible resources. As a result of this virtuous cycle, the stock of renewable resources will remain at a stable level, and substitutes will be available when exhaustible resources are used up. This can basically ensure an intergenerational equity where the next generation will have much the same development conditions as the present generation.

The participation of natural resources in distribution can also increase ecological benefits. Many studies have confirmed that the ecological benefits resulting from the supply of ecological services for men by natural resources (mainly renewable resources) are much larger than direct economic benefits. An integral natural ecosystem is the prerequisite for natural resources to provide ecological services. The objective of natural resources participating in distribution is to keep the stock of natural resources at a reasonable level and maintain the integrity and ecological balance of the natural ecosystem. Although this may lose some economic benefits in the short run, it will generate greater ecological benefits in the long run and increase the overall welfare and sustainability of men.

In summary, the system of distribution based on contribution of factors using the theory of compensation value is a reasonable distribution system that pays attention to intra-generational equity and economic efficiency in the short run, and balances intergenerational equity and ecological efficiency in the long run. So it is the best institutional choice for the sustainability of economy and natural resources.

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Chapter 21
Mechanism of Compensation for Non-commercial Forests in Shanghai

Liu Pingyang

There have been many studies on the compensation for non-commercial forests in China, and great achievements have been made in practice (Li et al. 2006). In 2001, China officially inaugurated the compensation fund for forest ecological benefits. By 2008, the central government had earmarked over RMB 10 billion for compensation of key national non-commercial forests. So far, over 20 provinces have enacted local policies on the compensation of forest ecological benefits, and the highest compensation is RMB 30/*mu* (Guangzhou). However, existing theoretical and practical studies focus on mountainous and forest areas, and there studies on the compensation for non-commercial forests in urban areas and plains are far from enough. The main reason might be that the size of non-commercial forests in plains is relatively small, and their ecological niches are not so sensitive. Moreover, forests in many cities are operated as green systems funded by public finance and there is no need for compensation.

21.1 Stability of Non-commercial Forests in Shanghai

Unlike their counterparts in other regions, non-commercial forests in Shanghai are developed in the land obtained through agricultural restructuring and land transfer. They adopt a market-based and socialized operating mechanism. According to No. 87 decree issued by Shanghai municipal government, which has a far-reaching effect, afforestation can be supported by forests and housing projects, and promoted by other projects. Also, low-density ecologically-friendly houses,

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sports and recreational facilities can be built in large forests at up to 30 % of the forest area. Spurred by large profits, a large amount of capital was invested in afforestation. Nearly 3 million *mu* of trees were planted within 3 years. But in 2014, the State Council stopped the practice of afforestation in farmland. As a result, the policy to support forests through housing projects couldn't be implemented. Enterprises, township governments and other organizations engaged in afforestation almost lose all the sources of profits and take on a heavy financial burden. On the other hand, due to inflation and land appreciation, the appeal of farmers for compensation increases. They demand higher land transfer fees, employment or urban social security. These pose a severe challenge to the stability of the nearly 0.7 million *mu* of non-commercial forests in Shanghai.

21.1.1 Afforestation Enterprises Are Overburdened

According to our survey that covered 10 suburban districts and counties, if an enterprise plants 10,000 *mu* of trees, the expenditures in 2003–2008 mainly included seedling cost (RMB 2000/*mu* exclusive of subsidies from municipal and district governments), investment in afforestation infrastructure (including land leveling cost and crop compensation which are estimated to be RMB 3000/mu), land transfer fee (RMB 600/*mu* per year), management cost (labor and material costs, RMB 700/mu) and operational expenditures. In total, the enterprise would invest RMB 125 million in 5 years, but hardly made any profit. So this enterprise is unable to continue its operation, and will try every means to cut costs. Some afforestation enterprises don't attend the forests, insecticide, fertilize or control weed. Some of them even default or refuse to pay the land transfer fee to farmers. As a result, farmers in Qingpu, Songjiang, Minhang and Jinshan repeatedly appealed to higher authorities for help.

21.1.2 Demands of Farmers Can't Be Met

The difficulty of afforestation enterprises is an important reason why the demands of farmers can't be met. On the other hand, Due to inflation, periodical rules of agricultural production and ownership (farmers are still owners of the land use right), the land transfer fee demanded by farmers keeps rising. The land transfer fee stipulated in agreements signed in 2002–2004 was about RMB 200–500/*mu* per year. After repeated fights with the government and afforestation enterprises, it is increased to the present RMB 500–1200/*mu* per year. Moreover, it can be expected that farmers will raise new requirements. Actually, in recent years, farmers are asking for urban social security and employment in addition to a higher land transfer fee.

21.1.3 Local Governments Are Overburdened

Local governments assume about 86 % of the afforestation target. Moreover, their afforestation and management costs are higher than those of afforestation enterprises. In principle, they need to bear half of the standard seedling cost (over RMB 4000 per *mu*). The management cost includes the pension, medical insurance and housing provident fund of forest management staff (RMB 885/mu). Like enterprises, they can hardly receive any return on these investments. This brings a huge financial pressure to local governments.

As non-commercial forests have specific location requirements, and afforestation is often based on agricultural restructuring, the less developed a region is, the larger the size of afforestation will be and the larger the afforestation and management burden will be. Geographically, the water conservation forests in the Huangpu riverhead region are mostly located in Songjiang and Qingpu districts. Coastal shelter forests are mostly found in Chongming and Nanhui districts. Chongming County is home to more than a third of the non-commercial forests in Shanghai. Within these districts and counties, the case is similar. For instance, water conservation forests are concentrated in the less developed Xinbang, Maogang, Yexie and Wushe of Songjiang District, and in Qingxi (Liantang and Zhaoxiang) of Qingpu District. "More forests, heavier burden" has become quite normal.

Moreover, the pressure of afforestation enterprises and farmers is eventually transferred to local governments. When enterprises can't afford the land transfer fee, local governments have to pay for them. When enterprises and farmers can't reach consensus on land transfer fee, local governments must provide some subsidies accordingly. Also, farmers will eventually turn to local governments for urban social security and employment. If the trees planted by enterprises are to be purchased by them, local governments will face even greater pressure. Consequently, the burden imbalance will become even worse.

The nearly 0.7 million *mu* of non-commercial forests in Shanghai are hard won. But due to the lack of an effective interest sharing mechanism, enterprises, local governments and farmers have lost the enthusiasm for protecting and managing these forests. Non-commercial forests have become burdens rather than appreciable ecological assets. On the other hand, over 95 % of the trees in non-commercial forests in Shanghai are young trees of singular species. The number of local species is quite small, there are many landscaping species and the community structure is simple, preventing the trees from to playing their due ecological functions. Investing in optimizing species structure and improving quality is both urgent and necessary. However, due to the lack of a proper responsibility sharing mechanism, these problems are now accumulating. At present, the stability of non-commercial forests in Shanghai can't be guaranteed. To change this situation, we must face squarely the attribute of non-commercial forests as public goods. The government must shoulder the principal responsibility and adopt a compensation mechanism for non-commercial forests. The core of this mechanism should be how to share the responsibility for non-commercial forests properly.

21.2 Establishing a Compensation Mechanism for Non-commercial Forests in Shanghai

21.2.1 Theory Framework for Ecological Compensation

The theoretical foundation of ecological compensation mainly includes the theory of public goods and the externality theory. Non-commercial forests can be divided into different levels of public goods according to the scope of ecological services. Governments at different levels should assume appropriate supply responsibilities. If they shoulder undue responsibilities, proper compensation should be provided. From the perspective of externality, the principal value of non-commercial forests is the value of ecological services which can hardly be realized through market. This gives rise to the inconsistency between the private cost/benefit of providers and the social cost/benefit, namely the positive externality. The ecological compensation in strict sense is the internalization of the positive externality.

As urban forests have a strong attribute of public goods, most urban forest construction and management activities in China and other countries are funded by government budgets. Market participation and social intervention only serve as beneficial supplements. In view of the peculiarity of non-commercial afforestation in Shanghai and its impact on the practicability of ecological compensation, some property rights of afforestation enterprises can be repurchased by the government. This actually constitutes one-time compensation provided by the government for enterprises. This not only makes ecological compensation more practical, but also enables differentiated government treatment for afforestation enterprises.

On this basis, the compensation for non-commercial forests in Shanghai can be divided into three levels.

First, the compensation for the micro subjects that generate positive externalities. After the property rights of non-commercial forests are streamlined by the government through repurchase, micro subjects related to corresponding positive externalities will include forest management subjects directly responsible for forest management, and farmers who transfer their land use rights.

Second, the supply responsibility for non-commercial forests that is reasonably distributed among regions. At the municipal level, the responsibility should be balanced among all districts/counties. At the district/county level, the responsibilities should be balanced among all towns. The afforestation and management costs of non-commercial forests are reasonably distributed mainly through the transfer of government payment.

Last but not least, the compensation for rural areas by urban areas. Restricted by the overall municipal development planning of Shanghai, the responsibility of developing agriculture is mandated to suburban areas. Moreover, suburban areas are both constructors and managers of non-commercial forests, which directly produce the externalities of ecological services. At present, they are not receiving appropriate returns. Instead, they are bearing heavier financial burdens. This part of development opportunity loss should be incorporated into the ecological compensation of Shanghai.

The compensation mechanism for non-commercial forests in Shanghai mainly refers to levels 1 and 2. It is mainly designed to provide a long-term mechanism for the maintenance and preservation of non-commercial forests. The highest level of ecological compensation, namely the compensation for development opportunity loss of suburban areas, should be compensated in the form of re-feeding rural areas by urban areas, re-feeding agriculture by industry and coordinating urban and rural development.

21.2.2 Establishment of Compensation Standards

Level 1 and Level 2 compensation mainly involve three costs, i.e. afforestation, tending, protection and management, specifically the afforestation, land transfer and forest management expenditures in Shanghai. As afforestation expenditure is a sunk cost, it should be solved through negotiations between related subjects. This paper will discuss the compensation standards for the other two costs.

Generally speaking, the compensation standards can be determined with the benefit-based method or the cost-based method (Chen and Wei 2003). The first method can't be realized because the value subjects of non-commercial forests can hardly be marketized (Dai et al. 2005). Therefore, the second method is used more often. As the ecological compensation mechanism is still at the initial stage in China, due to limited government budget, relatively lower compensation standards would be more practical.

21.2.2.1 Opportunity Cost of Land Management Right

The opportunity cost of land management right is in essence the land transfer free. A project team from Fudan University conducted a thorough survey on this issue in 10 suburban districts and counties in July 2008. See Table 21.1 for the survey results.

The current land transfer fee (paid by enterprises or town governments) is not a result of adjustments to initial contracts, but a result of constant games among farmers, enterprises and governments. Whether it is reasonable or not can be judged with the following two methods:

First, compare it with the present benefits of land management rights. The low land transfer fee in 2002 was closely related to the low benefits of grain growing at that time. According to our studies, the income per *mu* of farmland in 2002 was about RMB 500 (500 kg of unhusked rice at a price of around RMB 1/kg). After all costs are calculated, including RMB 45 for seeds, RMB 140 for chemical fertilizers and pesticides, RMB 25 for tractor ploughing, RMB 20 for water and electricity, RMB 10 for reaping and RMB 50 for agricultural tax, the

Table 21.1 Land transfer fee in 10 suburban districts/counties Shanghai

District/ County	Initial standard (RMB/mu)	Current standard (RMB/mu)	Remarks
Songjiang	360	600	
Qingpu	400	800	
Chongming	350 (price of 300 kg of rice)	614 (90 for each *mu* of private lots)	
Baoshan	300–500	1000 on average	(government subsidy: RMB 500/*mu*)
Minhang	600	1000–1200	–
Jiading	500	1000	–
Pudong	600	More than 10,000/mu	–
Jinshan	(price of 250 kg of rice)	600 (620 for each *mu* of ecological forests)	(afforestation subsidy from district government: RMBm100/mu)
Nanhui	800	1000	–
Fengxian	400	800–1200	–

net benefit per *mu* was RMB 210 inclusive of the labor cost. If each *mu* required 12 persons and the labor cost was RMB 30 per person, the net benefit per *mu* would be minus RMB 150. In 2004, both the central and municipal governments intensified support for agriculture, annulling the agricultural tax, distributing quality seeds for free, providing subsidies for chemical fertilizers and pesticides, increasing the grain purchase price and providing direct farming subsidies (RMB 250 per mu). As a result, the net benefit per *mu* inclusive of labor cost increased to RMB 680. Therefore, the current land transfer fee is relatively reasonable.

However, the farmland isn't only used to grow grain. If it is used to grow vegetables, the benefits will rise significantly. Taking Liantang Town of Qingpu District as an example, if farmers use the land outside vegetable-growing bases to grow wide rice stems, the net benefit can be RMB 4000 per *mu* inclusive of labor cost. Farmers whose land is incorporated in vegetable-growing bases can receive more benefits in forms of sales management and government subsidies. Compared with this benefit, the current land transfer fee is obviously too low. The research indicates that farmers in suburban areas generally use part of their farmland to grow grain and part to grow vegetables. Therefore, it's very difficult to determine the real opportunity cost of land management rights according to what is grown in the land.

Second, compare it with the spontaneous land transfer fee in rural areas. According to our survey, some land in Songjiang and Qingpu is rented to people from other places for RMB 400–500 per *mu*, and some land in Baoshan and Jiading is rented to people from other places to grow vegetables for RMB 1000 per *mu*. Such rents are not quite different from the actual land transfer fees paid to farmers in these areas.

Based on the above analysis, the compensation standard for opportunity cost of land management rights can be determined according to the current land transfer fee and the operating feasibility. We suggest a unified standard of RMB 1000 per *mu* every year in Shanghai.

21.2.2.2 Forest Management Cost

The present forest management cost mainly includes two parts:

1. Personnel expenses. According to the present management level, a management worker is required for each 20 *mu* of forests. The wages, pension, medical insurance and housing provident fund per worker is about RMB 1500/month, which can be converted into RMB 900/*mu*.
2. Material cost. According to the estimation of forestry stations in 10 districts/counties, the basic material cost is about RMB 300/*mu* per year as per the current demand for chemical fertilizers, pesticides and machinery.

Therefore, the compensation standard for the management cost is about RMB 1200/m per year. Compared with the management input of outer-ring green belts (RMB 2347/*mu*), it is obviously lower. So it can be increased to RMB 1300/*mu*.

21.2.2.3 Cost of Restructuring Non-commercial Forests

The land transfer fee and forest management cost only include the necessary input for maintaining existing forests. They are not sufficient for the non-commercial forests to grow from new forests into mature ones featuring complex community structures, high stability and strong ecological service functions. The restructuring of non-commercial forests and quality improvement constitutes the foundation of a long-term mechanism, and also the ultimate goal of ecological compensation.

However, as the restructuring demands of different types of non-commercial forests are different, it is hard to estimate the restructuring cost and the cost can't be shared. Therefore, this cost can be compensation by the following means.

1. Determine the restructuring priority of water conservation forests, coastal shelter forests, pollution prevention and isolation forests and passageway protection forests according to ecological sensitivity.
2. Assess the restructuring costs of various types of forests. The cost for non-commercial forests that benefit Shanghai should be shared among all districts/counties according to the overall municipal planning. The cost for forests that benefit a district/county should be shared among all towns according to the overall planning of the district/county. For forests that benefit several districts and counties, the cost should be shared among these districts and counties.

[1] Compensation for crops is one-time compensation and is not included.

In summary, the compensation standard for non-commercial forests in Shanghai can be RMB 2300/*mu*. The total annual compensation would be RMB 1.61 billion a year for 0.7 million *mu* of non-commercial forests.[1]

21.2.3 Compensation Implementation

The fund for ecological compensation can be obtained through two channels. First, it can be covered by the municipal budget. Second, it can be covered by district/county budgets. As the non-commercial forests benefit Shanghai, the municipal budget must provide compensation. However, as the division of fiscal revenue between district/county governments and the municipal government is 65 %:35 %, the cost should be partly covered by district/county budgets. For instance, municipal and district/county budgets can respectively cover 50 % of the cost. The share of separate districts/counties can be divided according to the administrative division/GDP/disposable revenue.

Each year, both the municipal and district/governments should inject their share into a forest ecological benefit compensation fund for non-commercial forests. The fund can be operated in an open, just and fair manner to minimize the loss caused by low operation efficiency.

21.3 Conclusions and Discussions

Non-commercial forests in Shanghai are uniquely characterized by the high cost caused by land transfer and afforestation and the complex mechanism of interest resulting from marketization. To protect the hard-won ecological construction fruit and to provide stable, long-term ecological services for Shanghai, it is necessary to reasonably share the obligations for non-commercial forests through an ecological compensation mechanism. Based on the existing theories and practices of ecological compensation in China, and in line with the peculiarity of Shanghai, a preliminary study of the compensation mechanism for non-commercial forests in Shanghai is conducted according to the principle of cost compensation. Compensation for farmers' land use right and forest management constitutes the principle part of the current non-commercial forest compensation mechanism, which costs about RMB 1.61 billion a year.

In addition, some compensation is not incorporated into the current scope of compensation for non-commercial forests. It mainly includes the following two parts:

First, social security and employment for land-expropriated farmers. Non-commercial forests in Shanghai are built in transferred farmland and can hardly be restored once the forests are grown. Therefore, farmers who transfer their land will become landless. According to the compensation requirements for landless farmers, their urban social security and employment should be solved first . In our opinion, however, this part of the compensation shouldn't be incorporated into the compensation mechanism for non-commercial forests. On the one hand, farmers only lose the land use right, and the land ownership is still in the possession of village collectives. The current compensation standard basically covers or even exceeds the benefit of farmers managing their land. If this compensation is stable in the long run, the opportunity cost of farmers is actually compensated. On the other hand, to provide urban social security and employment for farmers, the urban-rural dual structure needs to be broken and real national treatment should be granted to farmers. Therefore, it should be integrated into the overall development planning of Shanghai.

Second, loss of development opportunity of suburban areas. In general, ecological compensation should be provided for suburban areas. However, in the case of Shanghai, non-commercial forests are based on agricultural restructuring. Therefore, the development opportunity that suburban areas are deprived of is, in strict sense, the development opportunity of farming. In the short run, how the land in suburban areas should be used is strictly defined in municipal development planning. Therefore, compensation for this loss should be provided in the overall city planning. It shouldn't be limited to the compensation for non-commercial forests. Instead, it should be integrated into the compensation for rural areas by urban areas and for agriculture by industry.

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Chapter 22
Coordinated Environmental Protection and Socio-Economic Development in Ecological Function Reserves – A Case Study of Dongjiang Riverhead National Ecological Function Reserve

Li Zhimeng

In China's 11th Five-Year Plan, ecological function reserves are listed as restricted development zones, and one of the four function zones for land and space development. Important ecological function reserves have some special functions, such as maintaining ecosystem integrity and ensuring the sustainability of human material support system. They play an important role in water and soil conservation, flood storage, wind prevention, sand stabilization and maintenance of biodiversity. Since China launched the first pilot ecological function reserves in 2001, 18 national ecological reserves, and a number of intra-provincial ecological function reserves have been built. They play an important role in maintaining national and regional biological security, securing long-term stability and sustainable development. But important ecological function reserves are mostly located in ecologically vulnerable, poor and highly populated areas. They face much pressure in population growth, economic development and environmental protection. The ecological functions of some reserves have degrade or even been lost. "To enhance the construction of key ecological function reserves marks a major breakthrough and important measure in eco-environmental protection".[1] In our study, we will use the Dongjiang Riverhead National Ecological Function Reserve, the source of drinking water for seven million people in Hong Kong and the Pearl River Delta region in Guangdong as example, for empirical analysis. We will also, based on the construction of the Dongjiang Riverhead National Ecological Reserve, explore ways and support systems for coordinated environmental protection and socio-economic

[1] "Instructions of Vice Premier Zeng Peiyan" (Xu Suhui: Study of Ecological Compensation Mechanism for Dongjiang Riverhead National Ecological Function Reserve, The United Nations Symposium on Integrated Implementation of Sustainable Development Goals, Jiangxi, May 10 of 2005).

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development. This is an important task for protecting the current ecological function reserves and provides the foundation for building an environmentally-friendly society.

22.1 Foundation for Coordinated Environmental Protection and Socio-Economic Development in Ecological Function Reserves

22.1.1 Ecological Culture and Ecological Civilization

Ecological culture reflects human perception of the essential laws of natural ecosystem, and the total thoughts, ideas and consciousness of people for optimally addressing the relations between men and nature according to ecological relations. It also includes the measures adopted by men to address the ecological and environmental problems they face so as to better adapt to and transform the environment, and maintain the ecological balance for harmonious co-existence with nature and better survival and development of men, as well as strategies and institutions to ensure the smooth implementation of these measures. It reflects on and transcends traditional industrial civilization, and represents respect for and returning to natural laws at higher levels. In recent decades, the concept of ecological civilization has spread to economy, science, law, ethics, politics and other fields, signifying the transition from traditional industrial civilization to ecological industrial civilization and the adoption of natural laws as criteria to transform human production and life styles.

Before the emergence of men, all living things adapted to the environment through ecological adaptation for population reproduction. They evolved in the process of ecological adaptation. As environment evolves, so does human adaptability to social and ecological environment. While adapting to the environment, men also use culture to transform the environment. Men constitute a part of natural life system, in which men and other forms of life rely on and restrict each other. The relations between men and nature restrict the relations between men. To properly adjust men-nature relations, we need to coordinate the relations between men and nature, and pursue peace and progress for human society. Otherwise environment would degrade and civilization would decay. One of the disturbing facts about history is that so many civilizations have collapsed. Few people, however, least of all our politicians, realize that a primary cause of the collapse of those societies has been the destruction of the environmental resources on which they depended.[2] Thus, men's rights and responsibilities for the environment must be united, and the exploitation of natural resources must be balanced with the restoration of the

[2] [U.S.] Jared Diamond: Environmental Collapse and the End of Civilization (First Part), Digest of Foreign Social Sciences, 2003 (10).

environment. As resource consumers, men should take more environmental responsibilities, follow natural laws and subject themselves to natural laws. The ancient Chinese ideologies, including "Living with the universe, being the one with nature", and "He who is able to give full play to the nature of creatures and things can assist the transforming and nourishing powers of Heaven and Earth", which mirror the ideas of unity between men and nature, coexistence between men and nature and blessings for future generations, and the practice of cultivating geomantic forests and rotating crops and grass to maintain soil fertility represent traditional Chinese philosophical perception of ecology. In the mid-nineteenth century, Engels reminded people in the Introduction to *Dialectics of Nature* that "We should not be too intoxicated with the victory of our nature. For each such victory nature have its revenge on us". Because everything in universe follows an operation rule that transcends the subjective wills of men, "men must conform to the laws of nature". Humans have the right to enjoy material life and pursue freedom and happiness. However, this right must be limited to the environmental capacity to promote ecological civilization with ecological culture, to advance the harmonious coexistence between men and nature and to achieve sustainable socio-economic development.

22.1.2 Unity Between Economic Development and Environmental Protection

According to Professor Herman Haken, a German physicist and founder of synergetics, all systems can be divided into several subsystems. The system behavior we see is not always the simple superposition of behavior of all subsystems. Instead, it is the contribution of the synergy of subsystems to the whole system. The ecological economic system is a compound system made up of an economic subsystem and an environmental sub-system that constitute a unity of opposites. Under natural conditions, the two subsystems maintain a balance. However, when men drive the environmental subsystem towards economic development to meet their survival and development demands, the balance within the ecological system is broken. If the social subsystem can compensate the loss of natural system, concerted evolution and development will soon take place. An ecological function reserve falls into a natural ecosystem, whose capacity is renewable, recoverable and incremental, and constitutes an organic whole that is vital, resilient and catabolic. It can stand pressure and increase its own functions and capacity as long as the pressure doesn't exceed the threshold, and increase the output to provide more material wealth and optimal ecological benefits for men. But once the external intervention exceeds the ecological threshold, the ecosystem will be destroyed or even dismantled. When the exploitation of resources and discharge of pollutants by men exceed the capacity of environment, the self-balance and adjustment capacity of the environment will be destroyed, and environmental degradation will eventually take place.

Economic development and environmental protection are closely bounded and dialectically united. In the past, development was narrowly interpreted as economic development. But now, men have realized that economic growth is just part of development. The improvement of living environment and quality constitutes an important part of development. Environment and economy are two relatively independent systems that coexist. Particularly, economy is highly reliant on environment. Environmental conditions are the prerequisites for economic development. Without the support of environment, economy will recess. The maintenance of virtuous cycle between the economic and environmental subsystems will play a pivotal role in promoting sustainable economic development. To keep ecological balance, China divides the whole nation into four function zones, namely optimal development zones, prioritized development zones, optimized development zones, restricted development zones and forbidden development zones. It also makes ecological plans to define the focus of ecological construction and functions of different zones. In this context, we should put away the extensive development pattern that seeks economic development at the expense of environment, fundamentally transform the pattern of economic growth, seek the balance between economic development and environmental protection and "adhere to resource-efficient development, clean development and safe development for sustainable development".[3]

22.1.3 Exploration of Ecological Compensation Mechanism and Reserve Management Method

Coordinated economic development and environmental protection in ecological function reserves must embody social equity. Ecological compensation provides an effective means for coordinated socio-economic development, environmental protection and social equity in ecological function reserves. Theoretically, ecological compensation is based on two points. First, compensation to the ecological environment for ecological equity. Second, compensation among men for ecological responsibilities and equity in the distribution of ecological interests. The creation and improvement of compensation will be of great significance to develop a recycling economy and achieve sustainability. The Dongjiang Riverhead National Ecological Function Reserve is a strategic area for ecological construction in Jiangxi Province and the Pearl River watershed. In this restricted development zone, we must adhere to the dominant function of conserving water, maintain and enhance vegetation protection so as to make great contribution to ecological balance. Because of environmental protection in riverhead regions, the sound ecological environment will benefit not only local residents, but also the whole watershed. At present, the idea of paying for ecological environment is recognized

[3] Proposal of the CPC Central Committee for Formulating the Eleventh Five-Year Plan for National Economic and Social Development, adopted at the Fifth Plenary Session of the Sixteenth Central Committee.

by more and more people. As a result, the design of payment for environment covers more and more areas. At present, the balance between economic development and environmental protection, the levy of environmental tax, and inter-watershed ecological compensation are studied, put into trial and explored. Fair and reasonable sharing of expenditures for ecological benefits among all beneficiaries provides a positive and long-term solution to ecological restoration and water conservation in ecological function reserves. Many laws in China, including the *Forest Law*, *Water and Soil Conservation Law*, the *Grain for Green* policy, and the compensation fund for forest ecological benefits provide a legal framework for similar ecological compensation mechanisms. A compensatory mechanism for ecological benefits has been adopted in the Elbe River watershed of Europe, and the river watersheds in U.S. and Australia for many years. These practices of adopting ecological compensation mechanisms to share ecological benefits can be used as reference.

The protection of ecological functions is the common choice for regional ecological protection around the world. The symbiotic development of environmental protection and socio-economic advance is the prerequisite and guarantee for the sustainable development of human beings. It must be considered in the context of civilization transformation and value recasting to emphasize human care for nature and find a new fulcrum for environmental protection from the perspective of outlook on the world and values. Whether the environment can be protected depends on the management intensity of the government and competent authorities. Currently, the Ecosystem Approach management draws wide attention in the world. The IUCN World Parks Congress held in Durban, South Africa in 2003 proposed a new concept of reserve construction and management. It emphasized the application of modern system theories and methods to build reserves, and protect and improve ecosystems that have important ecological functions. It also emphasized that the construction and management of reserves are closely related to economic growth and social progress. Some ecological function reserves in China have tried to build and improve a support system for ecological function reserves so as to restore and improve ecological functions, develop ecological industries, protect the green mountains and clean rivers, help people get rich and achieve coordinated environmental protection and economic development.

22.2 Major Reasons for Uncoordinated Environmental and Socio-Economic Development in Ecological Function Reserves

22.2.1 Restraints of Poverty and Local Protectionism

Poverty has a profound impact on the environment, and easily leads to the vicious cycle of environmental degradation and poverty. Ecological function reserves are mostly located in remote mountainous areas and rural areas where the economy is less developed and some local residents are still living in poverty. Population expansion often brings along large-scale land reclamation, and the huge population pressure poses a huge threat to the natural environment. Currently, the population density in natural reserves of China is over 60 persons/km^2. Under these circumstances, people tend to think about how to develop and how to change their own life, but give little consideration to or even ignore environmental pollution and ecological destruction. As the natural ecosystem is quite vulnerable, improper exploitation will easily lead to environmental degradation. On the other hand, poverty often gives rise to local protectionism. As governments at all levels have very limited resources and they need to boost local economic development, they can only guarantee their own economic interests within their respective capacity. Once there is a new investment hot spot, local governments would leverage the limited resources they can control to invest. This will lead to small initial business investment, sparse and repeated investment, diseconomies of scale and low-level repetition. Some enterprises are quite eager for quick success and instant benefits. To compete with other players and grab market shares, they put resources into production at low costs or regardless of costs. This can cause severe waste of resources and ecological destruction. Also, because of low resource costs, enterprises often neglect technological renovation and quality improvement. Such an extensive economic growth pattern is destructive to the environment in two aspects. On the one hand, it wastes precious resources and accelerates the exhaustion of resources. On the other hand, it emits/discharges too many pollutants into the environment and increases the burdens of the environment. Such a pattern of local economic development will eventually end up with the waste and exhaustion of natural resources.

22.2.2 Defects in Ecological Function Reserve Management Systems

Currently, China adopts a rescue-oriented and compulsory protection policy in ecological function reserves. In terms of resource management, enclosed protection measures are taken. The protection agencies and institutions established in this context aren't able to establish partnership with local communities, lack the mechanism for the participation of local communities and residents and neglect the basic contradiction between the development of reserves and the development of local communities. So they actually broaden the gap between them.

The establishment of ecological function reserves restricts the local use of resources and the confines local industrial development and environmental capacity, but fails to provide a policy and approach for proper compensation and alternative development. As a result, local residents often have quite small vested interest but need to shoulder protection responsibilities at their own expenses. Moreover, due to insufficient support from the government, these reserves often embark on a road of development to offset severe fund shortages and increase incomes through various channels. In this process, they are inclined to earn special interests through special power. Such an unfair interest mechanism would often lead to the dissatisfaction of local residents. Consequently, conflicts would arise between the construction of reserves and the life of local residents, which in turn would affect the enthusiasm of local residents for protecting ecological resources.

In China, an inter-regional coordination mechanism has yet to be established. Currently, due to the differences between upstream and downstream regions in functional planning, environmental capacity and environmental function standards, the conflicts between development and protection are quite acute in and among administrative areas. Moreover, the survival and development rights for people in the upstream and downstream regions have remained unequal for a long time. The fragmented division between administrative areas in a watershed significantly hampers the coordination between upstream and downstream regions, restricts the protection of ecological functions, and the support for socio-economic development in the whole watershed. This will eventually lead to the unsustainability of these administrative areas.

22.2.3 Lack of Environmental Protection System Innovation and Motivation Mechanisms

At present, one orientation resulted from the current environmental protection system in China is that environmental protection is the responsibility of the government, consumers and enterprises are passive observers of the system. There is no motivation and compensation for voluntary system observance. Once there is a loophole in the system or adequate supervision is absent, they will take advantage of the policy loopholes. Lumbering and excess mining in riverhead regions have done great harm to the Yangtze River, the Yellow River and other rivers in China. As a result of point-source industrial pollution and domestic sewage pollution, the once clean and beautiful Huaihe River and Taihu Lake paid huge resource and environmental costs, experiencing quality-induced water pollution and declining water quality. As such, the government spent hugely on water pollution prevention and control projects. Frequent occurrence of sprawling algae in Taihu Lake and Chaohu Lake marks the beginning of intensive water pollution and water pollution crisis across China. The water environmental conditions in China are now at a dangerous critical point, which concern the subsistence of people, social stability and national security. These facts indicate the development pattern of traditional industrialization has brought the resource environment in China to an unbearable bottom line. Moreover, they signify that some existing environmental protection systems need to be improved and innovated. In the presence of strict systems, once the default costs of enterprises or individuals exceed benefits, they will inevitably make rational choices after balancing the costs and benefits. This shows that to increase the default costs of subjects is the foundation of system innovation. But now, environmental destruction is just an external diseconomy for enterprises, which doesn't have a direct impact on their operations in the short run. Therefore, enterprises don't have the desire for environmental protection technologies or the enthusiasm and conscientiousness for innovating environmental protection technologies.

22.3 Major Problems Facing Ecological Protection and Construction in Dongjiang Riverhead Region

The Dongjiang riverhead region is a national ecological function reserve primarily designed to conserve water. The Dongjiang River is the principal source of drinking water for residents in Hong Kong. It originates in Xunwu, Anyuan and Dingnan counties of Jiangxi Province. The riverhead region covers an area of 3502 km^2 or about 10 % of the whole watershed area of the river. With mountains covering 90 % of the total area, this region is rich in forest resources. The average forest coverage rate is up to 79.6 %. The rich biodiversity brings many premium biological resources. There are 273 families of higher plants, 284 genera and 2260 species, including 28 national endangered plant species. This region is rich in green mountains, clean water, beautiful scenery and other tourism resources. It boasts a long history and profound culture, represented by the Hakka culture. Known as the tungsten capital of the world and kingdom of rare earth, it is rich in mineral resources, particularly, tungsten, lead, zinc, molybdenum and rare earth. The annual mining capacity can be 25.74 million tons. The environmental quality of this region is quite good. The quality of surface water of most rivers is equal to or better than the national Grade-II surface water quality standard. The quality of water flowing out of the province is often above the national Grade-II surface water quality standard. Local governments and people have been engaged in forest and ecological construction to enhance the water conservation capacity in the riverhead region for many years. As a result, vegetation in this region is good enough to provide an important ecological shelter for downstream regions. However, this region still faces some serious environmental protection and construction problems.

22.3.1 The Conflicts Between Ecological Protection and Socio-Economic Development Are Quite Acute

The riverhead region is abundant in non-ferrous metals, rare earth and forest resources. However, due to the special ecological function definition and geographical location, to better protect the source of drinking water, these resources can't be intensively exploited. Therefore, resource advantages can't be converted into economic advantages, severely hindering local economic development. Impoverished people in the three counties make up 42 % of the total. Xunwu and Anyuan are state-level poverty-stricken counties and Dingnan is a provincial-level poverty-stricken county. In 2004, the GDP of the three counties totaled RMB 3.103 billion and the per capita GDP was RMB 3612. Local fiscal revenues aggregated to RMB 240 million and the per capita was RMB 284.7. The per capita net income of farmers was RMB 2012 or about 70 % of the per capita net income of farmers in Jiangxi Province and Ganzhou City, 46 % of the per capita net income of farmers in Guangdong and 7 % of the per capita net income of farmers in the Pearl River Delta region. The economic and social development of the three counties remained at the bottom of Jiangxi Province and Ganzhou City for a long time. The conflict between urgent investment in ecological protection and construction in the riverhead region and limited local government financial resources is quite acute. Particularly, as it is difficult to find a way conducive to protecting the ecological environment and shaking off poverty, the enthusiasm and conscientiousness of local people for ecological protection is severely affected. Guangdong Province, which is adjacent to the region and benefits from the river, is quite rich, particularly the Pearl River Delta region. Economic growth in these areas is fueled by flexible economic policies. For instance, Dongguan and Shenzhen are now among the richest regions in China. Because economic growth in Dongjiang riverhead has been quite low in recent years, local people have long been aspired to become rich. In the context of a broadened income gap with surrounding areas, this aspiration can easily lead to blind energy release. This region now faces a typical conflict between environmental protection and economic development. Natural and pollution-free water is quite vulnerable. Any minor error or carelessness would lead to pollution that is hardly recoverable, posing potential threats to Hong Kong, Shenzhen and other cities. The consequences would be quite severe. Therefore, to achieve coordinated environmental protection and economic development in this region and to carry out whole-process control of environmental protection is of strategic implication.

22.3.2 The Declining of Ecological Functions Is Not Fundamentally Controlled

Due to history, population, resources and development patterns, the mining industry in the riverhead region dominated by rare earth and tungsten, the fruit industry focusing on navel orange, the breeding industry represented by large pig farms are all at the initial stage when the pressure to environment is at the highest level. The intensity of supervising and funding ecological protection is quite limited. Consequently, the trend of declining ecological functions is not fundamentally controlled. This is manifested in the following four aspects.

22.3.2.1 The Water Conservation Capacity Decreases

Although the overall forest coverage in the Dongjiang riverhead region keeps increasing, due to irrational structuring of tree species, needle-leaved forests make up about 78 % of the total forest area. This leads to inadequate water conservation capacity. Before 1990, the annual mean runoff in the watershed area was 30.01×10^8 m^3, and the annual mean flow rate was 95.2 m^3/s. The annual mean groundwater resources reached 990 million m^3, and the runoff recharge coefficient was 0.33. In 1991–2001, the annual mean runoff and the runoff recharge coefficient respectively dropped 4.9 % and 6.1 % over the previous years. Currently, the exploitation rate of water resources of Dongjiang River is about 30 %, which is expected to rise to 40 % by 2010. Compared with the international average rate of 40 %, it is necessary to carry out environmental assessment, life research and ecological health studies. The Dongjiang riverhead region is not only the source of Dongjiang River, but also possesses 10 % of the total water resources. Therefore, it is ecologically, economically and politically important to protect and distribute water resources in the riverhead region.

22.3.2.2 Water Loss and Soil Erosion Is Still Quite Severe

In recent years, although water loss and soil erosion control has been intensified in Dongjiang riverhead region and the area of water loss and soil erosion has slightly decreased, the men-induced water loss and soil erosion in development and construction projects has not been fundamentally controlled. According to statistics, the soil erosion modulus in Dongjiang watershed is 4280 t/km^2, and the annual soil loss amounts to 418.4×104 t. As a result, the river bed rises and the flood prevention and drought relief becomes more difficult. This constitutes a direct threat to the Dongjiang-Shenzhen Water Supply project. The ecology becomes vulnerable in water loss and soil erosion area, the biodiversity is destroyed and the natural succession function of the ecosystem declines. Because of water loss and soil erosion, the agricultural production conditions and the ecological environment deteriorate. Moreover, the water, soil and fertility conservation capacity of soil deteriorates, and the ability to resist natural disasters drops. As a result, the agricultural output falls and becomes unstable, and the income of farmers lingers at a low level for a long time. The water loss and soil erosion hinders sustainable socio-economic development, which in turn restricts the investment in water loss and soil erosion control.

22.3.2.3 The Conflict Between Population and Land Exacerbates

In the Dongjiang riverhead region, the area of farmland per capita is less than 0.6 *mu*. The reserve of land resources for reclamation is in shortage, and most of it is located in less developed and isolated mountainous areas, which make it difficult to reclaim these land resources. As the population naturally grows, the land required for various construction purposes increases and some farmland is de-farmed for ecological purpose, the conflict between population and land will be more severe.

22.3.2.4 Wetland Destruction and Natural Disasters Pose Substantial Damages to the Ecological Environment and Bio-Diversity

Many original wetlands in the riverhead region are turned into farmland, or used to build roads or other buildings. Some rivers with good quality water are converted into fish ponds water quality where the water quality deteriorates. As a result, the role of wetland in purifying water and regulating water flow falls. Some artificial wetlands added to the reservoirs that are built after the founding of the People's Republic of China in 1949 have a compensation effect. But artificial wetlands are quite different from original ones in terms of biodiversity. Their benefits in water supply, flood prevention, and power generation are quite remarkable, but their role in protecting biodiversity is inadequate. Natural disasters in the region mainly include drought, rainstorm, floods, low temperature, rain, slope collapse and geological disasters. Particularly, droughts, floods and geological disasters have huge impacts and cause enormous losses. The occurrence rate of summer droughts is 80–90 %, and the droughts normally last 30–50 days or even 80 days in the region. Floods caused by rainstorm happen from time to time, damaging houses, farmland, water conservancy, transport and communication facilities. Ecological environments are characterized by poor vegetation species and biological stability, which jeopardizes the biodiversity.

22.3.3 Environmental Pollution Is Quite Severe

As urban infrastructure severely lags behind in the riverhead region, domestic garbage and sewage are directly discharged into water bodies without being properly treated. Moreover, extensive agricultural production and irrational mine exploitation make the pollution situation even worse.

22.3.3.1 Pollution of Water Bodies Deteriorates

Some enterprises directly discharge sewage that contains COD, ammonia and nitrogen into the Dongjiang River and its tributaries. Moreover, domestic sewage and garbage from towns along the Dongjiang River are also discharged into the river. As a result, the overall water quality of the river becomes worse. In some stretches, the water quality of the river only meets Class IV surface water quality standard. If the pollution is not well controlled, the Dongjiang River Watershed will experience pollution-induced water shortage. This will directly compromise the security of drinking water for the middle and lower reaches, particularly Hong Kong.

22.3.3.2 Agricultural Diffused Pollution Directly Affects the Environment

Due to the irrational agricultural production, overuse of pesticides, chemical fertilizers, agricultural film and the pollution caused by livestock and poultry breeding, agricultural diffused pollution will exacerbate in degree and scope. In 2004, the usage (pure quantity) of pesticides in orchards and farmland was up to 36.3 kg/km^2, and the usage (pure quantity) of chemical fertilizers was up to 435.3 kg/km^2. A significant portion of the pesticides and chemical fertilizers flows into water bodies. Also, some increment of livestock and poultry is also to blame for the pollution of water bodies. The large amount of nitrogen, phosphor and potassium that is carried into water will potentially lead to water eutrophication.

22.3.3.3 Problems Left Over by History Are Prominent, and Ecological Damage Caused by Mining Is Serious

In the riverhead region, there are now several thousand mines. Outdated and obsolete, these mines causes much damage to natural vegetation and landscape, and even triggers subsides, ground fissures, landslides, slope failures and other secondary geological disasters. The piling of slag in large quantities and irrational discharge of sewage also pollutes farmland soil and water bodies. According to some statistics, the size of mine areas in urgent need of reclamation is now 46.21 km^2 in the riverhead region. In some areas, due to irrational mine exploitation, groundwater resources begin to decline and the ecological environment becomes imbalanced. If effective measures are not taken in a timely manner, associated radioactive substances and hazardous metal ions will cause disastrous consequences once they pollute the river.

22.3.3.4 The Integrated Supervision Capacity of Ecological Environment Is Quite Weak

The Dongjiang Riverhead Ecological Function Reserve covers a total area of 3502 km^2 in Xunwu, Anyuan and Dingnan counties. The existing supervision system needs to be further intensified. First, there is no integrated and coordinated management agency. A well-targeted management mechanism and a system of appropriate policies, laws and regulations have yet to be established. Second, supervision technologies and measures are quite obsolete and are not able to provide accurate information on ecological protection in the riverhead region in a timely manner, making it hard to bring the ecological service functions into full play.

22.3.4 *The Input System Doesn't Meet the Requirements of Enhancing Ecological Protection and Construction*

The financial resources of the three riverhead counties are quite week and insufficient. This has impaired the enthusiasm of local governments and particularly local people for ecological protection. Consequently, the effect of ecological measures drops and ecological control projects are progressing slowly. Up to now, an inter-provincial (region/city) coordination mechanism has yet to be adopted for environmental management and an ecological compensation mechanism based on sharing ecological interests has yet to be established. Strong technical support can nowhere be found for ecological compensation. The role of public participation and market mechanism is not brought into full play. These factors hinder the process of ecological construction and protection and make it difficult to implement many ecological protection rules and regulations.

22.4 Build a Support System for Coordinated Environmental Protection and Economic Development in Ecological Function Reserves

To achieve the symbiosis of environment and economy in ecological function reserves is a long-term and comprehensive task that requires a well-established support system. To protect and enhance dominant ecological functions in the riverhead region, ensure the safety of drinking water for Hong Kong and the Pearl River Delta region, achieve sustained and harmonious environmental protection and economic development in the region, a support system should be established.

22.4.1 *Establish an Ecological Function Restoration and Development System*

We should adopt an ecosystem approach to preserve and enhance ecological functions of the forest ecosystem and the soil ecosystem, and gradually realize the transformation of ecosystem from reverse succession to positive succession. The development of productivity creates necessary material and technical conditions to address environmental problems that are mainly caused by improper or inadequate development and must be solved through development. On the one hand, the renewability of environmental resources should be enhanced and ecological destruction mitigated. On the other hand, only when productivity is developed can people shake off poverty, restore the ecology and improve the environment. We should gradually achieve the ecological transformation of outlook on technology, and recognize that the self-adjustment of the ecosphere is irreplaceable, and that technological advancement should fall in line with ecological development. In addition, we should transform the traditional value that men conquer nature to the value characterized by co-evolution between men and nature. Moreover, we should be attentive to the natural restoration capacity of ecology and responsible for future generations.

An ecological function restoration and development system should be established in the reserve. To this end, we should focus on cultivating and protecting forest resources to enhance the ecological shelter function of forestry. First, we should strengthen the protection of water conservation areas, intensify vegetation protection and restoration in the riverhead region, step up the sealing off mountainous areas for afforestation, accelerate the construction of water conservation forests, and improve the stand quality. We should also enhance the construction of forest ecosystem, maintain and increase the water conservation capacity and runoff. Counties in the riverhead region should remain convicted to ecologically-friendly development. Anyuan County, for example, has stopped the production of Shiitake mushroom which contributes one fifth of China's total export, banned charcoaling, prohibits lumbering in an area of 382.59 km^2 in and around Sanbai Mountain, and built a 66.67-km^2 core natural reserve and a 200-km^2 of water conservation forest. The harvest volume of commercial forests dropped from 60,000 m^2 in 1997 to the present 15,000 m^2. It has also completely sealed off mountainous areas for afforestation, and maintains a well-established ecosystem in Sanbai Mountain. Second, we should control the discharge of pollutants and build an index system for the ecosystem. As such, we should enhance supervision and early warning, check mining, quarrying, brick making and other enterprises that go against water conservation, adopt sealing off and banning measures, organize technical staff to nurture and replant trees, control pests and diseases, improve breeds and protect the vegetation in ecological restoration areas. Moreover, we should control agricultural and living point-source pollution, strengthen the protection of water resources and wildlife diversity which serves as the barometer of ecological environment in the watershed region and enhance the ecological restoration in mining areas. Dingnan County has stipulated that no mining site should be set up in the 1114-km^2 Jiuqu River watershed. Xunwu County has closed 106 mining sites and enhanced the construction of reserve so as to meet the objectives specified in the *Decision of the Standing Committee of Jiangxi Provincial People's Congress on Enhancing the Ecological Protection and Construction in Dongjiang Riverhead Region*: significantly improve the quality of water environment to bring the overall water quality to national Grade-II standard, effectively increase the water conservation capacity, give full play to the ecological functions by 2015 and build a national demonstration ecological function reserve with sound ecological environment and beautiful scenery. On top of these, we should fundamentally transform the economic growth pattern, and find a balance between economic development and environmental protection. In addition, we should strive to achieve the evolution of the complex ecosystem of nature, men and society so that it is more reasonable and better coordinated.

22.4.2 Build a Sustainable Resource Utilization System

We should properly handle the relations between the exploitation and development of land resources, water resources, forest resources and mineral resources for more efficient utilization of these resources. We should also, according to the ecosystem productivity theory, study factors that restrict the exploitation of resources, and establish an economic development pattern based on resource environmental capacity. To build the Dongjiang Riverhead National Ecological Function Reserve, local governments have taken rescue-oriented measures in key ecological function areas and compulsory measures in key resource exploitation areas. In addition to banning mineral exploitation in the core ecological function areas in the riverhead region, local governments have also stipulated the conformity of new mining projects to the general planning of mineral resources, and prepared environmental impact assessment reports, water conservation plans and geological disaster assessment reports. Also, they adopt proactive strategies in areas with good ecological environment, and accelerate the restoration of regional ecological quality and the reconstruction of ecological environment. The riverhead region is one of the major rare earth producing areas in China. Because of lagging economy and spurs of interests, rare earth was once mined in a confused manner. Consequently, the vegetation of the mountains was destroyed, the surface soil was stripped off, and ravines and gullies appeared through the mountains. These caused severe soil loss and environmental pollution. In the mid-1990s, some new technologies were propagated, and the new in-situ leaching mining method that does not destroy the vegetation and can retrieve rare earth was adopted. The application of this method has displayed an obvious effect, as the problem of environmental destruction caused by mining is well addressed. The requirement to protect the environment reduces optional development paths. Fortunately, the application of new technologies can expand the development space. It can get rid of pollution, and more importantly, reduce the cost to avoid the conflict between economic development and environmental protection. Local governments in the riverhead region stringently manage mining exploitation and strictly prohibit resource-intensive and high-polluting mines to fundamentally solve the problem of structural pollution, and well protect the mountains and vegetation. Due to afforestation, green mountains and clean water have now come back. The green productivity characterized by clean production, recycling economy and ecological economy is not only a pillar of advanced productivity, but also an optimal “binding point” for productivity development and sustainable resource utilization.

22.4.3 Build an Ecological Industry and Recycling Economy

The environment and industrial development are highly correlated. The formulation and implementation of industrial policies will directly or indirectly affect the environmental system. The industrial orientation and distribution should respect natural laws, and conform to the functional zoning requirements and environmental capacity of the watershed. Moreover, an environmental impact assessment system should be put in place for these industrial policies. We explore an environmentally-friendly economic development pattern to fuel the transformation of economic growth pattern in the riverhead region. Environmental sustainability can't simply be measured by maintaining environmental renewability and biodiversity. Protective development is the prerequisite for sustainable development of ecological function reserves. Management purely for the purpose of ecological protection or development simply for the purpose of developing economy will eventually end up with a failure to achieve the predefined objectives. For economic development in the riverhead region, we must take measures in line with local conditions, leverage unique ecological and cultural advantages, develop industries that conform to the orientation of the reserve and well coordinate the relations between economic, natural and social development so as to optimize the comprehensive benefits. To develop the economy, we must give top priority to protection when studying the industrial system in the riverhead region. First, we should consider the impact of the industry on the environment, restructure the industry and promote industrial ecologicalization. We should never develop the economy in such a dangerous manner as quenching a thirst with poison. Otherwise, the environment will be severely damaged and the sustainability of the region eventually jeopardized. Second, on top of innovating ideas, we should conscientiously develop an ecological industry. To this end, we should make full use of all positive modern technological achievements to facilitate the appreciation of renewable natural resources and develop substitutes for non-renewable natural resources. The ecological industry is significant in that it restores ecological cycles and mitigates environmental pressure, and more importantly it ensures the sustainability of the human material support system. Therefore, the selection of dominant industries is paramount, i.e. low-emission, environmentally-friendly and resource-efficient industry, agriculture and service industries. At present, an ecological tourism industry is growing in the riverhead region to attract Hong Kong, Guangdong and overseas tourists to explore the river source, rich historical resources, local customs and Hakka culture. A fruit industry underpinned by moderate, reasonable and scientific plantation of pollution-free navel oranges, an ecologically-friendly agriculture featuring ecological cycle between pig breeding, biogas production and fruit plantation, a processing industry capitalizing on the rich forest and bamboo resources, and rare earth mining industry are all gaining momentum in the region. The selection and further development of these dominant industries will help convert the resource advantages into economic advantages and build up economic sustainability on the basis of resource sustainability.

22.4.4 Create a Harmonious Social System

The construction of a harmonious community and the construction of an ecologically-friendly community in the riverhead region should be combined so that the local population and economic development can adapt to the environmental capacity. First, we need to arouse people's awareness of environmental security, build a concept of environmental security and establish an effective community participation mechanism. Environmental protection can't simply rely on campaign-style initiatives launched by government. Instead, it requires the active participation of the public and a long-term mechanism to legally ensure effective public participation. This is the foundation of environmental protection. We should guide local people to accept the ideas that to protect the environment is to protect productivity, to improve the ecological environment is to increase productivity, and that clear waters and green mountains equal gold hills and silver hills. This way, they will realize that nature is the support for human life, that the respect and care for life is not something that men generously bestow on other forms of life, but the necessity for the advancement of men. The compulsory resource conservation in natural reserves to some extent restricts the utilization of local resources as well as local way of production and life. The construction of an ecologically-friendly community and the construction of a harmonious community in the riverhead region are united. The construction of the ecological function reserve can increase the profile of the local community. It can also facilitate the communication between the local community and the outside world, the introduction of advanced resource utilization technologies, the transformation of traditional production pattern and the development of local tourism and other related industries. This will eventually improve the local environment to some extent. On the other hand, the construction of the natural reserve requires the support and help of local people. The participation of local people can help reduce management costs and divert some local population from reliance on resources to sustain life to resource management, thus mitigating the pressure of the local community to resource conservation. This shows that there is no inevitable conflict between poverty relief and environmental maintenance. The conflict between them in reality is often attributed to the way adopted for poverty relief or for environmental protection. The allegation that poor farmers are less environmentally aware mainly indicates that they may not voluntarily and conscientiously protect the ecological environment. But they should know how to protect the land, forests and other natural resources they rely on for subsistence. They always carefully maintain the resources that they stably own and use. When the resource environment deteriorates, local farmers are always the first to suffer. Therefore, guiding policies and complete institutions must be in place for the innovation of reserve management model so that local residents can maintain the sustainability of resource environment.

Second, the total population should be strictly controlled and the quality of population improved so as to gradually eliminate the ecological pressure caused by poverty. By improving the quality of population, we can effectively lower the population growth rate, facilitate the family planning initiative and the healthy growth of future generations. We can also utilize resources more efficiently. Functional reserves are mostly located in remote mountainous areas, where the scientific and cultural qualities of people are quite low, and some people are even illiterate or semi-illiterate. The improvement of population quality can help increase job opportunities for them and upgrade their social status. When the scientific and cultural qualities of farmers are improved, they can rid of poverty and become better off at a faster pace, and the blind and destructive utilization of resources can be mitigated. Moreover, the ecological pressure caused by population can be eased. To this end, some programs should be launched to provide vocational training for famers so as to improve their working and entrepreneurial skills. Surplus laborers in rural areas can be organized to work in the Yangtze River Delta, the Pearl River Delta and Fujian Province. In this way, the pressure of local people to ecological environment can be effectively mitigated. For instance, an ecological immigration program has been kicked off. During the 11th Five-Year-Plan period, 33,000 farmers will be moved out of the riverhead region and relocated for poverty relief. To develop economy in the riverhead region, we must improve the quality of population, efficiently use resources, mitigate environmental pollution and pay attention to quality and benefits to unify the construction of a harmonious community and the construction of an ecologically-friendly community in the region.

22.4.5 Establish a Policy System to Support the Preservation of Ecological Functions

First, an ecological compensation policy should be adopted and inter-regional cooperation enhanced. We must ensure the sustainability of water resources of the Dongjiang River. The top priority is to manage the river resources as a whole and allocate them in a reasonable manner. To this end, a water right system should be established and improved to define the use rights of water resources. Inter-regional and inter-watershed cooperation should be enhanced to solve major environmental problems and protect the place where people live. To protect the ecological environment in the riverhead region, help local people become rich and deliver clean water to Guangdong and Hong Kong, Jiangxi has launched a RMB 1.42-billion ecological protection and construction project in the riverhead region. This project involves the construction of ecological forests, water conservation, ecological restoration in mines, ecological agriculture, flood prevention, control of agricultural diffused pollution, ecological tourism, ecological immigration, ecological environment surveillance and information management. For a long time, Jiangxi has attached great importance to the ecological protection in the riverhead region. The *Decision of the Standing Committee of Jiangxi Provincial People's Congress on Enhancing the Ecological Protection and Construction in Dongjiang Riverhead Region* enacted in 2003 was the first local regulation in China for the ecological protection in Dongjiang riverhead region. In 2004, Jiangxi prepared the *11th Five-Year Plan for Ecological Protection and Construction in Dongjiang Riverhead Region*. Governments at all levels in the riverhead region also issued a number of policies and measures. In addition to technical support, a large amount of fund is also needed. It is unfair for the riverhead region to bear all the required financial investment. This will result in a broader socio-economic development gap between upstream and downstream regions, and make it more difficult to attain the objectives of developing economy as a whole and building a harmonious society in the region. Therefore, costs for ecological benefits must be fairly and reasonably shared among all beneficiaries. An ecological compensation mechanism should be adopted for the riverhead region so as to transform the practice that mountain dwellers live off the mountain to one that mountain dwellers are engaged in mountain management for a living.

Second, an industrial support policy should be established. Shenzhen, Hong Kong and other places in the watershed should invest in the south of Jiangxi in the name of compensating water resources, and develop ecologically-friendly industries through cooperation. Policy support should be rendered to effectively address development problems in the riverhead region. Local farmers should be guided to embark on a road of becoming rich through ecologically-friendly industries so as to lay a solid foundation for ecological restoration. A mechanism should be established and improved to diversify investment, and the climate for investment in environmental protection should be improved. Moreover, a Dongjiang Riverhead Ecological Fund should be established to further expand fund channels for environmental protection by pooling governmental and non-governmental support from places sharing Dongjiang River water resources, absorbing funds from international organizations and business community, and attracting investment in environmental protection.

Third, a national, local and departmental coordination mechanism should be established to define the supervision and management responsibilities of the central government, Jiangxi, Guangdong and Hong Kong. Governments at all levels in the riverhead region should, through comprehensive coordination and unified supervision, put in place a well-established environmental supervision system. The fulfillment of environmental protection responsibilities should be integrated as an important part into the performance assessment of local leaders so as to urge them to establish a concept of integrated environmental protection. In addition, the existing institutional barriers and technical constraints should be removed. A mechanism for inter-provincial/city coordination on environmental supervision should be enhanced. Moreover, a green national economy accounting system and an environmental auditing system should be adopted. Technologies to quantify and monetize resources and benefits should be gradually introduced to provide powerful technical support for ecological compensation. Moreover, efforts should be employed to make the water cleaner and sky bluer in the riverhead region so that people in Hong Kong can have safe drinking water and people in the riverhead can live a better life. In this way, we can promote the virtuous cycle of ecosystem and sustainable socio-economic development in the riverhead region, and enable all stakeholders to carry out cooperation in more areas.

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Chapter 23
Resource Valuation of Baiyangdian Wetland

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Baiyangdian Wetland lies in the center of Hebei Province, between 115°38′–116 ° 07′ east longitude and 38 ° 43/−39 ° 02′ north latitude. It runs 39.5 km from the east to the west and 28.5 km from the south to the north. The water area varies with the water level. When the water level is 10.5 m (measured at Shifangyuan), the total area of the wetland will be 366 km^2. In recent years, due to water block by reservoirs in the upstream region and severe pollution, the ecological balance has been damaged. Wild birds are rarely seen and some fishes are even extinct. The main reason behind this is people's failure to fully realize the service value of local ecosystem. The measurement and calculation of the ecological value of Baiyangdian Wetland will be of great significance to arouse attention to wetland resources and guide people to develop wetland resources in a reasonable manner.

23.1 Value Composition of Baiyangdian Wetland

23.1.1 Functional Analysis of Baiyangdian Wetland

The function of a wetland ecosystem refers to its ability to maintain natural processes, to directly or indirectly provide various resources and energy for men, and to prevent natural disasters. To analyze the functions of Baiyangdian Wetland is to analyze the functions of the local ecosystem functions. By summarizing the existing research findings and combining the characteristics of Baiyangdian Wetland, functions of the wetland can be categorized into economic, ecological and social functions.

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Table 23.1 Value composition of resources of Baiyangdian Wetland

Use value	Direct use value	Material production, tourism, education and scientific research
	Indirect use value	Water supply, flood diversion and storage, pollutant degradation, climate regulation and biodiversity maintenance
Non-use value	Existence value	
	Heritage value	
	Option value	

23.1.2 Value Composition of Baiyangdian Wetland

The value of Baiyangdian Wetland is closely related to its functions. The value of the wetland, namely the total economic value of the wetland, refers to the total economic value of all services provided by the wetland for the economic system. It consists of two parts, i.e. use value and non-use value. The former is made up of direct use value and indirect use value. The latter includes existence value, heritage value and option value. Different types of value have different implications and contents. See Table 23.1 for detailed functions of Baiyangdian Wetland.

23.2 Use Value of Baiyangdian Wetland

23.2.1 Direct Use Value

23.2.1.1 Material Production

Known as a land flowing with milk and honey, Baiyangdian Wetland abounds in natural resources. In our study, the widely distributed and representative reed, fish, crustacean and shellfish are selected as assessment objects. As material products have clear market prices and can be exchanged in market, a market-based evaluation approach is adopted to assess their value.

1. Reed. Reed in the wetland is white, soft, pliable, tough and durable. Therefore, it can be used as material for reed craft and papermaking. In 2006, the output of reed in the wetland reached 23,490 tons. If the reed is used to make reed screen, reed mat and paper, the value would be RMB 113.3133 million.
2. Aquatic products. Fishery in the wetland mainly consists of fishing and aquaculture (Table 23.2). The total area of aquaculture is 4003 hm^2, covering 1308 hm^2 of ponds, 2266 hm^2 of lakes, 407 hm^2 of brooks and ditches and 22 hm^2 of other places. The total output value of aquatic products amounts to RMB 172.62

Table 23.2 Aquatic products of Baiyangdian Wetland

Type	Output (t)	Type	Output (t)
Fishing	22,187	Aquaculture	7680
Fish	16,338	Fish	6745
Crustacea	835	Crustacea	281
Shellfish	3854	Shellfish	654
Others	1160	Others	–

million. After costs of material, service and other intermediary consumption are deducted, the net output value would be RMB 85.73 million per year.

The total material production value of the wetland is RMB 199.0433 million a year.

23.2.1.2 Tourism

Baiyangdian Wetland is home to beautiful sceneries and rich tourism resources. It has been a famous tourist attraction since ancient times, boasting a high tourism value. The tourism value can be assessed with the travel cost method. The formula is as follows:

$$\text{Travel cost} = \text{travel expenditure} + \text{consumer surplus} + \text{value of travel time}$$

$$\text{Here, travel expenditure} = \text{number of tourists per day} \times \text{travel expense per day} \times \text{travel time per year;}$$

$$\text{Consumer surplus} = \text{travel expenditure} \times 40\%;$$

$$\text{Value of travel time} = \text{total travel time} \times \text{opportunity cost per unit of time.}$$

In 2006, Baiyangdian received 0.81 million tourists, bringing in a direct income of RMB 44.14 million. Hence, the travel cost was RMB 44.14 million, and consumer surplus RMB 17.6560 million. According to the average wages and travel time in Beijing, Tianjin and Hebei, if the opportunity cost per unit of time is 1/3 of the wage cost, it can be deduced that the value of travel time is RMB 2223.56. Therefore, the travel cost of the Baiyangdian Wetland is RMB 84.04 million, and the tourism value is RMB 84.04 million a year.

23.2.1.3 Education and Scientific Research

This value includes the value of education and the value of scientific research.

The value of education mainly refers to what tourists gain in terms of education. The ecosystem, diverse animal and plant communities, historical and cultural relics such as the temporary imperial residence of Emperor Kangxi of Qing Dynasty in Baiyangdian Wetland are all educationally valuable. So the wetland can be regarded as a large museum. According to the average admission price of natural museums in Beijing, Tianjin and Hebei and the number of tourists, the value of education can be as high as RMB 26.325 million a year.

The value of scientific research is normally calculated according to the investment in scientific research and the actual expenditures of researchers. As little research is carried out on the Baiyangdian Wetland and there is no statistics on research investment, the value of scientific search of this wetland can't be calculated according to the investment in scientific research and the actual expenditures of researchers. In our study, the value is calculated with the benefit transfer method. According the evaluation of Chen Zhongxin and Zhang Xinshi for the research value of wetland ecosystems in China (RMB 382/hm^2) and the evaluation of Costanza et al for the research value of wetland ecosystems around the world (US $ 881/hm^2), after price index and exchange rate are used for revision, the average can be used as the value of scientific research per unit of area. According to hydrologic data, the area of Baiyangdian Wetland was 87.67 km^2 in 2006. So the value of scientific research is RMB 0.6924 million a year.

Therefore, the total value of education and scientific research of Baiyangdian Wetland is RMB 27.0174 million/year.

23.2.2 Indirect Use Value

23.2.2.1 Water Supply

The value of water supply refers to the value of water resources provided by Baiyangdian Wetland for industry, agriculture and cities. It can be interpreted as the value of water storage. To make sure there is enough water in the wetland and the interests of surrounding areas are not harmed, some research institutions have clearly specified the maximum permissible water level and holding volume of the wetland to be 10.5 m and no 440 million m^3. Based on the reservoir construction cost of China in 1988–1991 (RMB 0.67 for 1 m^3 of storage capacity), with the price changes in 1990–2006 taken into consideration, the storage cost per unit of storage capacity in 2006 was determined to be RMB 1.41/m^3. If the service life of reservoirs is 50 years, the value of water supply of Baiyangdian Wetland is:

$$\begin{aligned}\text{Value of water supply} &= \text{total water storage} \\ &\quad \times \text{ storage cost per unit of storage capacity } /50 \\ &= \text{ RMB 12.410 million}/\text{year}\end{aligned}$$

23.2.2.2 Flood Diversion and Storage

Baiyangdian Wetland played an important role of flood diversion and storage in all previous flood seasons. So it is particularly important to assess the value of flood diversion and storage. According to the specification on water level, the wetland's capacity available for flood diversion and storage is 290 million m^3. Therefore, the value of flood diversion and storage is:

$$\begin{aligned}\text{Value of flood diversion and storage} &= \text{capacity for flood diversion and storage} \\ &\quad \times \text{ storage cost per unit of storage capacity}/50 \\ &= \text{RMB 8.178 million/year}\end{aligned}$$

23.2.2.3 Pollutant Degradation

In recent years, thanks to effective control and strict management of water pollution, water pollution in Baiyangdian Wetland caused by tributary rivers has been significantly reduced. The water discharged by enterprises around the wetland is compliant to statutory standards. At present, the pollution sources of the wetland mainly include residual chemical fertilizers used in agriculture, excrement from animal breeding and tourism. As no data on pollution of animal breeding and tourism is available, we will only assess the wetlands' value in terms of degrading fertilizers.

In 2006, the usage of chemical fertilizers in the wetland area reached 5713 tons. If the actual utilization rate of chemical fertilizers is 35 %, the amount of fertilizers flowing into the wetland would be 3713.45 tons. According to the shadow project approach and after the cost of SO_2 (RMB 600/tons) is deducted, the cost to treat the fertilizers flowing into the wetland would be RMB 2.2281 million/year. In other words, the value of pollutant degradation would be RMB 2.2281 million/year.

23.2.2.4 Climate Regulation

The value of wetland in terms of climate regulation is mainly embodied in the absorption of CO_2 and then the release of O_2 and CH_4 by plants to regulate atmospheric constituents. CH_4 is the second most important greenhouse gas on our planet after CO_2. Therefore, when assessing the value of climate regulation, we should not only consider the positive impacts of CO_2 release and absorption, but also the negative impact of CH_4 release.

1. CO_2 absorption and O_2 release. According to the data on hydrology and reed in Baiyangdian Wetland in previous years, it can be deduced that the area of reed in the wetland is about 4600 hm^2. According to the ecological conditions, we can calculate that the wetland can produce 38,177.33 tons of organic substance in

reed a year. According to the photosynthesis equation, we can deduce that the wetland can fix 62,213.78 tons of CO_2 and release 45,484.47 tons of O_2 a year. The unit value of carbon sequestration can be deduced according to the rate of carbon tax. At present, there are a number of carbon tax rates in the world. At the most representative carbon tax rate levied in Sweden which is US$ 150/tons or RMB 1195.5/tons, the value of carbon sequestration of the wetland is RMB 74.345 million a year. The value of O_2 release can be calculated with the project alternative method. At the cost of industrial oxygen production which is about RMB 400/tons, the value of oxygen released by the wetland is about RMB 18.1938 million/year. Therefore, the total value of carbon sequestration and oxygen production of the wetland is RMB 92.5393 million/year.

2. Greenhouse gas emissions. The greenhouse gas CH_4 emitted from Baiyangdian Wetland mainly comes from reed. According to the average flux of CH_4 emissions by reed, which is 0.520 $mg \cdot m^{-2} \cdot h^{-1}$, the total emission from the 4566.67 hm^2 of reed in the wetland would be 6495.45 kg a year. According to the figure used by David W. Pearce with OECD for wetland valuation, which is US$ 0.11/kg, we can deduce that the loss of CH_4 emissions by Baiyangdian Wetland is RMB 7.145 million/year.

Consequently, the value of Baiyangdian Wetland in terms of climate regulation equals the total value of CO_2 absorption and O_2 release minus the value of greenhouse gas emissions, i.e. RMB 85.3943 million/year.

23.2.2.5 Biodiversity Maintenance

The value of Baiyangdian Wetland in terms of biodiversity maintenance can be calculated with the shadow project method. The wetland can be regarded as a zoom of the same size. If the minimum investment in a zoom of the same size is RMB 100 million and service life of the zoo is 20 years, the value of the wetland in terms of biodiversity maintenance would be RMB 5 million/year.

23.3 Non-use Value of Baiyangdian Wetland

The non-use value of Baiyangdian Wetland should be calculated with the CVM method.

23.3.1 Rate of WTP and Per Capita WTP

For the assessment, 257 samples were randomly selected from farmers in Baiyangdian Wetland, tourists to the wetland and typical urban residents in Beijing,

Table 23.3 WTP for non-use value of Baiyangdian Wetland

Region	Valid samples	Amount people are willing to pay (RMB)	Rate of WTP (%)
Local farmers	39	24	61.54
Tourists	24	17	70.83
Beijing	31	9	29.03
Tianjin	22	9	40.91
Hebei	127	66	51.97
Total	243	125	51.44

Tianjin and Hebei. 243 valid questionnaires were recovered, so the rate of validity was 94.55 %. The analysis of the 245 valid samples shows that 125 people are willing to pay a certain amount of money to protect and improve Baiyangdian Wetland, so the rate of willingness to pay (WTP) is 51.44 % (Table 23.3).

According to the calculation, 42.80 % and 72.80 % are closest to the accumulative frequency median which is 50 %. The corresponding WTP values are respectively RMB 50 and RMB 100. The WTP value corresponding to the cumulative frequency median is RMB 62. Therefore, the per capita WTP for areas within the influence of Baiyangdian Wetland is RMB 62.

23.3.2 Statistics of Payment Orientation and Motivation

The survey of payment orientation is designed to find out which expenses the respondents are willing to pay among the natural landscape and ecosystem, rare wildlife and vegetation in Baiyangdian Wetland. The result indicates that of the 125 samples, 100 samples are willing to pay for the natural landscape and ecosystem (80.00 % of all samples), 8 samples are willing to pay for wildlife (6.40 % of all samples) and 17 samples are willing to pay for the vegetation (13.60 % of all samples).

The survey of payment motivation is designed to find out the proportion of existence value, heritage value and option value in the total WTP of the respondents. The result indicates that 47.54 % of the respondents are willing to pay for the sustained existence of Baiyangdian Wetland, 30.29 % are willing to pay so that future generations can see the wetland, and 22.17 % are willing to pay so that the resources of the wetland can be better used in the future. In other words, the proportion of existence value, heritage value and option value are respectively 47.54 %, 30.29 % and 22.17 %.

23.3.3 Calculation of Total WTP Value

Regions within the influence of Baiyangdian Wetland mainly include Beijing, Tianjin and Hebei. Therefore, samples for assessing the wetland's non-use value with the CVM method are primarily residents in Beijing, Tianjin and major cities of Hebei. After calculating the per capita WTP value of these samples, the total WTP value can be deduced. That is to say, we can determine the non-use value of Baiyangdian Wetland by deducing the total WTP value of Beijing, Tianjin and Hebei from the per capita WTP value. The per capita WTP of these samples is RMB 62. According to the population size and structure of Beijing, Tianjin and Hebei, the total WTP is RMB 5658.74 million. At the interest rate of 5 %, the annual WTP is RMB 282.937 million/year.

According to the total WTP (non-use value) and proportions of different parts, the existence value, heritage value and option value is respectively RMB 134.5082 million, 85.7016 million and 62.7271 million.

Apparently, the total value created by Baiyangdian Wetland is RMB 706 million/year. This includes RMB 423 million or 59.94 % of the total for use value,, and RMB 283 million or 40.06 % of the total for non-use value. The use value is a little larger than the non-use value. In the use value, the direct use value is RMB 310 million or 73.2 % of the total; and the indirect use value is RMB 113 million or 26.8 % of the total. The direct use value is larger than the indirect use value.

In conclusion, the concept and practice that overestimate the direct use value of Baiyangdian Wetland while underestimating the indirect use value are wrong. When developing, using and protecting the wetland, we should see the whole picture, fully understand various functions and values of the wetland resources and capitalize on these functions and values for three-dimensional and multiple use of wetland resources. In this way, we can bring the protection and utilization of wetland resources into harmony and eventually utilize the wetland resources in a sustainable manner.

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Chapter 24
Analysis of Factors Affecting Ecological Consumption Behavior of Urban Residents

Zhu Hongge

24.1 Introduction

To advocate and establish an ecological consumption pattern in the whole society is a prerequisite for achieving ecological civilization, developing recycling economy and building a resource-efficient and environmentally-friendly society. Generally speaking, to build an ecological consumption pattern in the whole society, we should start from enterprise production and resident consumption. For enterprises, various motivation and penalty measures can be taken to guide them to develop recycling economy and adopt environmentally-friendly and energy-efficient technologies. However, enterprises have to consider the increase of cost arising out of these efforts that may affect the market competitiveness of their products. So the support of consumers is required. Therefore, the force that drives enterprises to pursue recycling economy fundamentally comes from consumers. Only when consumers are willing to consume in an ecologically-friendly manner and pay for the premium that results from this, and the payment is transferred to enterprises through market can the demand for ecological consumption build up in society. The ecological consumption behavior of urban residents, as important consumers, is significant to building an ecological consumption pattern in the whole society.

Ecological consumption behavior actually consists of two types of behavior: the behavior to purchase ecologically- and environmentally-friendly commodities, and the behavior conducive to environmental protection and resource conservation in the process of consumption. The former can be further divided into two types of behavior. First, the purchase of ecologically- and environmentally-friendly commodities that are favorable for the environment, and the safety and health of

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consumers, such as organic food. Such commodities are called the first type of ecologically- and environmentally-friendly commodities. Second, the purchase of ecologically- and environmentally-friendly commodities that are favorable for the environment and have no impact on the safety and health of consumers, such as paper made by paper mills that apply emissions reduction technologies. Such commodities are called the second type of ecologically- and environmentally-friendly commodities. Consumers are motivated to purchase the second type of ecologically- and environmentally-friendly commodities by a sense of social responsibilities. This requires them to reach a certain spiritual state, and it is also the bottleneck of building an ecological consumption pattern. This paper only focuses on the purchase of ecologically- and environmentally-friendly commodities and analyzes factors that affect the purchase of each of the two types of commodities.

24.2 Literature Review

Currently, domestic studies of theories and policies on ecological consumption are concentrated on three aspects. First, the reasonable connotation of ecological consumption. Research on this aspect mainly illustrates the concept of ecological consumption and differentiates ecological consumption from related concepts, such as green consumption, moderate consumption and sustainable consumption [1]. Second, the role of government in pushing ecological consumption patterns, particularly in terms of publicity, laws and regulations, taxation and subsidies [2]. Third, the construction of ecological consumption systems in urban areas. Li Yangfan et al [3] built the ecological consumption system of Yangzhou City, and prepared the action plan for ecological consumption of residents. In their empirical analysis of factors that affect ecological consumption, Wang Jianmin et al. [4] did a survey on whether residents of Wuhan City would choose commodities with ecological labels and recyclable packages. They concluded that gender, marriage, age, employment conditions and other demographic features have a significant impact on ecological consumption behavior. More scholars chose pollution-free or green food to study the ecological consumption behavior of residents. They concluded that age, income and other individual features and the recognition of related food directly affect the purchase behavior of consumers [5–6]. The study of food with ecological labels by Cui Chunxiao and Xuan Ya'nan [7] was specific to pollution-free eggs. They found that the degree of education, gender and attention to egg safety significantly affect consumers' choice of eggs with ecological labels, while income only has a significantly negative impact on the purchase of pollution-free eggs.

Ecological consumption is seldom mentioned in foreign literature. But there is a tremendous amount of literature on sustainable consumption. This shows that foreign scholars incorporate the reasonable connotation of ecological consumption into the connotation of sustainable consumption. The psychological factors that affect consumers' ecological consumption are one of the highlighted parts in empirical studies by foreign scholars [8–9], followed by the empirical studies of consumer attitude toward ecological consumption and the willingness to pay for ecological consumption [10–11]. In brief, foreign studies of ecological consumption are concentrated on quantitative analysis and empirical analysis. This is in great need in China.

24.3 Theoretical Analysis of Factors Affecting Ecological Consumption Behavior

The purchase of ecologically- and environmentally-friendly commodities by consumers is a type of ecological consumption behavior. It is affected by many factors that can be roughly grouped into four categories: consumer cognition of ecological consumption, policies on ecological consumption, features of ecologically- and environmentally-friendly commodities and features of individual consumers.

24.3.1 Cognition of Ecological Consumption

Factors in the category of consumer cognition of ecological consumption include the cognition of ecological consumption, conformity and trust in green marks.

1. Cognition of ecological consumption. It refers to the level of consumer cognition of the concept or pattern of ecological consumption, i.e. whether and how much consumers know about ecological consumption.
2. Conformity. It refers to whether consumers are affected by the public when purchasing ecologically- and environmentally-friendly commodities, namely whether there is a conformable psychology to buy what others buy.
3. Trust in green marks. Green marks refer to a type of demonstration trademarks attached to products or their packages, proving that the products meet quality requirements, and conform to requirements on environmental protection in the process of production, use and disposal. Green marks convey a message to consumers, telling them what products are favorable for the environment and guide them to buy and use such products. But some outlaws would fake green marks to deceive consumers so that consumers become doubtful about the authenticity of green marks on commodities.

24.3.2 Policies on Ecological Consumption

The establishment and popularization of an ecological consumption pattern, to a great extent, requires the government to publicize this consumption pattern which is conducive to ecological civilization. Policy publicity is an important factor that reflects the policies on ecological consumption.

24.3.3 Features of Ecologically- and Environmentally-Friendly Commodities

Ecologically- and environmentally-friendly commodities have many features. One of the important features is the quality of these commodities. When buying such products, consumers need to pay a certain amount of premium on top of the price of ordinary commodities. The quality or performance of ecologically- and environmentally-friendly commodities must reach or exceed that of ordinary products. This is the basic condition for consumers to buy ecologically- and environmentally-friendly commodities.

24.3.4 Features of Individual Consumers

Features of individual consumers include age, gender, degree of education and monthly family income.

1. Age. Theoretically, the impact of age on ecological consumption behavior is not clearly oriented. The older the consumers are, the less capable they are of accepting information, the lower their cognition of ecological consumption may be, and consequently the less likely they are to choose ecological consumption. However, there are also some consumers that are more experienced and more sensitive to social responsibilities and more likely to choose ecological consumption.
2. Gender. Generally, men have more opportunities to receive education and expose themselves to the outside world than women, and they outperform women in terms of risk tolerance, ability to accept information and decision making. Therefore, the willingness to choose ecological consumption varies in gender.
3. Degree of education. Usually, the higher degree of education people receive, the more ready they are to accept new things and new knowledge, the broader their horizons will be and the more sensitive they will be to social responsibilities. Therefore, the degree of education has an impact on the willingness of consumers to opt for ecological consumption.
4. Monthly family income. Generally speaking, members of families with higher incomes are more capable of paying for more expensive ecologically- and environmentally-friendly commodities. But we cannot take it for granted that they are willing to pay for such commodities. However, monthly family income

should have an impact on the willingness of consumers to opt for ecological consumption.

24.4 Empirical Model, Sample Profile and Variable Specification

24.4.1 Empirical Model

This paper studies the willingness of urban residents to choose ecological consumption. It implies whether consumers are willing to buy ecologically- and environmentally-friendly commodities, including the scenarios of being willing or unwilling to buy. As discussed above, the willingness of consumers to buy ecologically- and environmentally-friendly commodities is affected by four categories of factors, namely consumer cognition of ecological consumption, policies on ecological consumption, features of ecologically- and environmentally-friendly commodities and features of individual consumers. The relations among them can be summarized in the following function:

Willingness of residents to choose ecological consumption = F (consumer cognition of ecological consumption, policies on ecological consumption, features of ecologically- and environmentally-friendly commodities and features of individual consumers) + random disturbance term

In our study, whether consumers are willing to by ecologically- and environmentally-friendly commodities is used as a dependent variable, namely type 0–1 dependent variable (y = 1 if consumers are willing to participate, and y = 0 if consumers are unwilling to participate). If the probability of y = 1 is P, the distribution function of y would be:

$$f(y) = P^y(1-P)^{1-y}; y = 0, 1 \tag{24.1}$$

In our study a two-dimension logistic model is used to limit the value of the dependent varible between 0 and 1, and the maximum likelihood estimation method is used to estimate the regression parameter. The form of the logistic model is as follows:

$$P_i = F\left(\alpha + \sum_{j=1}^{m} \beta_j X_{ij} + u\right) = 1/\left\{1 + \exp\left[-\left(\alpha + \sum_{j=1}^{m} \beta_j X_{ij} + u\right]\right]\right\} \tag{24.2}$$

Here, P_i is the probability of consumers being willing to buy ecologically- and environmentally-friendly commodities; i is the number of consumer; β_j is the regression coefficent of the affecting factor; j is the number of affecting factor, m represents the number of affecting factors; X_{ij} is an independent variable which represents the number *j* affecting factor of sample *i*; and α is a constant term and *u* is an error term.

24.4.2 Sample Profile

Data In our study was derived from field survey in the form of questionnaire comprising 16 questions. The survey was conducted in department stores, supermarkets and building material markets, covering consumers in Xiangfang, Nangang, Daoli and Daowai districts of Harbin. A total of 300 questionnaires were delivered and 289 valid questionnaires were recovered.

24.4.3 Variable Specification

When surveying whether consumers are willing to buy ecologically- and environmentally-friendly commodities, variables used included the consumer cognition of ecological consumption, policies on ecological consumption, features of ecologically- and environmentally-friendly commodities and features of individual consumers. The variables of consumer cognition included the cognition of ecological consumption, conformity, and trust in green marks. The variable of policies on ecological consumption included publicity of policies. The variable of features of ecologically- and environmentally-friendly commodities included the quality of commodities. The variables of features of individual consumers included age, gender, degree of education and monthly family income. See Table 24.1 for model variables, Tables 24.2 and 24.3 for the statistical descriptions of all variables.

24.5 Result of Empirical Analysis and Discussion

24.5.1 Optimization Results

In our study, the SPSS13.0 statistical software was used for logistic regression of sample data. First, dependent variable Y1 and all independent variables were introduced into the regression equation for significance test of all regression coefficients to yield a regression model for consumer purchase of the first type of ecologically- and environmentally-friendly commodities. This model was called Model 1. See Table 24.4 for the results. Then dependent variable Y2 and all independent variables were introduced into the regression equation for significance test of all regression coefficients to yield a regression model for consumer purchase

Table 24.1 Variable selection and assignment

Variable	Code	Value range	Assignment instructions
Purchase of the first type of ecologically- and environmentally-friendly commodities	Y_1	0–1	No = 0; Yes = 1
Purchase of the second type of ecologically- and environmentally-friendly commodities	Y_2	0–1	No = 0; Yes = 1
Cognition of ecological consumption	X_1	0–3	No = 0; moderate = 1; good = 2; very good = 3
Conformity	X_2	0–1	No = 0; Yes = 1
Trust in green marks	X_3	0–1	No = 0; yes = 1
Publicity of policies	X_4	0–1	No = 0; yes = 1
Reliability of commodity quality	X_5	0–1	No = 0; yes = 1
Age	X_6	1–4	Below 29 = 1; 30–44 = 2; 45–59 = 3; above 60 = 4
Gender	X_7	0–1	Female = 0; Male = 1
Degree of education	X_8	1–4	Primary school and below = 1; junior high school = 2; senior high school = 3; junior college and above = 4
Monthly family income	X_9	1–5	Below RMB 1500 = 1; RMB 1500–3000 = 2; RMB 3000–5000 = 3; RMB 5000–10,000 = 4; above RMB 10,000 = 5

of the second type of ecologically- and environmentally-friendly commodities. This model was called Model 2. See Table 24.5 for the results.

24.5.2 Discussion

The logistic model regression results in Table 24.4 show the purchase of the first type of ecologically- and environmentally-friendly commodities by urban residents of different ages, genders, degrees of education and monthly family incomes. The statistics indicates that consumer cognition of ecological consumption and publicity of policies are significant at the 1 % level, consumer cognition of green marks is significant at the 5 % level, and reliability of commodity quality and degree of education are significant at the 10 % level. All other variables are not significant.

The logistic model regression results in Table 24.5 show the purchase of the second type of ecologically- and environmentally-friendly commodities by urban residents of different ages, genders, degrees of education and monthly family incomes. The statistics indicates that consumer cognition of ecological consumption and publicity of policies are significant at the 1 % level, consumer cognition of

Table 24.2 Statistical description of variables when consumers consider purchasing the first type of ecologically- and environmentally-friendly commodities

	Purchase intention	Cognition of ecological consumption	Conformity	Trust in green marks	Publicity of policies	Reliability of commodity quality	Age	Gender	Degree of education	Monthly family income
Minimum	0	0	0	0	0	0	1	0	1	1
Maximum	1	3	1	1	1	1	4	1	5	5
Average	0.79	0.97	0.31	0.44	0.27	0.70	1.61	0.47	3.39	2.07
Standard deviation	0.409	0.711	0.465	0.497	0.443	0.460	0.793	0.500	0.802	0.944

Table 24.3 Statistical description of variables when consumers consider purchasing the second type of ecologically- and environmentally-friendly commodities

	Purchase intention	Cognition of ecological consumption	Conformity	Trust in green marks	Publicity of policies	Reliability of commodity quality	Age	Gender	Degree of education	Monthly family income
Minimum	0	0	0	0	0	0	1	0	1	1
Maximum	1	3	1	1	1	1	4	1	5	5
Average	0.45	0.96	0.31	0.47	0.22	0.70	1.61	0.47	3.39	2.07
Standard deviation	0.499	0.709	0.465	0.500	0.414	0.458	0.796	0.500	0.802	0.944

Table 24.4 Results of logistic model regression for consumer purchase of the first type of ecologically- and environmentally-friendly commodities

Independent variable	B	S.E.	Wald	df	Sig.	Exp(B)
Cognition of ecological consumption	0.749	0.262	8.169	1	0.004***	2.115
Conformity	−0.236	0.340	0.484	1	0.486	0.789
Trust in green marks	0.938	0.381	6.044	1	0.014**	2.554
Publicity of policies	1.478	0.518	8.157	1	0.004***	4.386
Reliability of commodity quality	0.667	0.342	3.801	1	0.051*	1.948
Age	−0.031	0.213	0.021	1	0.885	0.970
Gender	0.241	0.328	0.540	1	0.462	1.272
Degree of education	0.355	0.197	3.241	1	0.072*	1.426
Monthly family income	0.223	0.186	1.427	1	0.232	1.249
Constant term	−1.903	0.909	4.379	1	0.036**	0.149

Note: (1) Optimization results: −2LL = 242.745; Cox and Snell x^2 =0.174; Nagelkerke x^2 =0.270 (2) * indicates significance at the 0.1 level; ** indicates significance at the 0.05 level; and *** indicates significance at the 0.01 level

Table 24.5 Results of logistic model regression for consumer purchase of the second type of ecologically- and environmentally-friendly commodities

Independent variable	B	S.E.	Wald	df	Sig.	Exp(B)
Cognition of ecological consumption	0.663	0.209	10.108	1	0.001***	1.941
Conformity	0.351	0.290	1.466	1	0.226	1.421
Trust in green marks	0.592	0.276	4.612	1	0.032**	1.808
Publicity of policies	1.457	0.348	17.483	1	0.000***	4.294
Reliability of commodity quality	0.621	0.315	3.884	1	0.049**	1.861
Age	−0.249	0.178	1.949	1	0.163	0.779
Gender	0.516	0.269	3.685	1	0.055*	1.675
Degree of education	−0.119	0.178	0.442	1	0.506	0.888
Monthly family income	−0.214	0.145	2.188	1	0.139	0.807
Constant term	−0.980	0.766	1.637	1	0.201	0.375

Note: (1) Optimization results: −2LL = 333.271; Cox and Snell x^2 =0.201; Nagelkerke x^2 =0.269 (2) * indicates significance at the 0.1 level; ** indicates significance at the 0.05 level; and *** indicates significance at the 0.01 level

green marks and reliability of commodity quality are significant at the 5 % level, and gender is significant at the 10 % level. None of the other variables is significant.

1. Consumer cognition of ecological consumption. The regression results in Tables 24.4 and 24.5 show that consumer cognition of ecological consumption has a positive impact on the purchase of the two types of ecologically- and environmentally-friendly commodities. Consumers that know more about ecological consumption are more inclined to purchase the two types of commodities. Consumer cognition of ecological consumption Exp (B) in Model 1 is higher than that in Model 2, indicating that the impact of cognition on the purchase of the first type of commodities is higher than that on the purchase of

the second type of products. Consumer cognition of ecological consumption directly affects their understanding and judgment of ecologically- and environmentally-friendly commodities, and decides their valuation of and attitude toward ecologically- and environmentally-friendly commodities, which in turn affect their purchase.

2. Consumer trust in green marks. The regression results in Tables 24.4 and 24.5 show that consumer trust in green marks has a positive impact on the purchase of the two types of ecologically- and environmentally-friendly commodities. Consumers that have more trust in green marks are more inclined to purchase the two types of commodities. Consumer trust in green marks Exp (B) in Model 1 is higher than that in Model 2, indicating that the impact of trust on the purchase of the first type of commodities is higher than that on the purchase of the second type of products. It is not difficult to understand that if consumers don't trust green marks, they will not purchase ecologically- and environmentally-friendly commodities.
3. Publicity of policies. The regression results in Tables 24.4 and 24.5 show that the publicity on policies has a positive impact on the purchase of the two types of ecologically- and environmentally-friendly commodities. The Exp (B) value of this variable is very high in both models, indicating that government publicity on ecological consumption largely decides whether consumers will purchase ecologically- and environmentally-friendly commodities.
4. Reliability of commodity quality. This variable is significant in both models, but more significant in Model 2. Reliability of commodity quality has a positive impact on the purchase of the two types of ecologically- and environmentally-friendly commodities. The quality and reliability of ecologically- and environmentally-friendly commodities also largely affect the purchase of consumers.
5. Conformity. The results in Model 1 show that conformity has a negative impact on the purchase of the first type of commodities, indicating that consumers don't follow suit when purchasing the first type of commodities. The results in Model 2 show that conformity has a positive impact on the purchase of the first type of commodities, indicating that consumers follow suit when purchasing the second type of commodities. However, the impact of conformity is not significant in both models.
6. Gender. The regression results in Tables 24.4 and 24.5 show that gender has a significant impact on the purchase of the second type of commodities, while its impact on the purchase of the first type of commodities is insignificant. This indicates that men are more inclined to purchase the second type of commodities than women. Although men are also more inclined to buy the first type of commodities, the impact of gender is not significant.
7. Degree of education. The regression results in Tables 24.4 and 24.5 show that degree of education has a significant impact on the purchase of the first type of commodities, but its impact on the purchase of the second type of commodities is insignificant. This indicates that consumers with a higher degree of education are more inclined to purchase the first type of commodities. But the degree of

education has a negative impact on the purchase of the second type of commodities, though the impact is insignificant.

8. Age. The above analysis indicates that the impact of age is not clear. The regression results of Tables 24.4 and 24.5 show that the impact of age is negative. This indicates that young people are more inclined to purchase ecologically- and environmentally-friendly commodities, but the impact is insignificant.
9. Monthly family income. Previous empirical studies show that income has a significant impact on consumption. Regression results of Tables 24.4 and 24.5 show that income has a little impact on the purchase of the two types of ecologically- and environmentally-friendly commodities, and the impact on the purchase of the second type of commodities is negative. The reason behind this may be that the respondents were all middle income earners, and consumers had little cognition of ecological consumption.

24.6 Conclusions and Policy Implications

In our study, 289 residents in Harbin of Heilongjiang Province are used as examples. Regression models are built for the purchase of ecologically- and environmentally-friendly commodities that are favorable for the environment and consumers, and the purchase of ecologically- and environmentally-friendly commodities that have no impact on consumers to analyze main factors that affect the ecological consumption of urban residents. The results show that the cognition of ecological consumption, trust in green marks, publicity on policies and reliability of commodity quality have a significant impact on the purchase of the two types of commodities, and the impact is positive. Gender and degree of education are demographic factors that respectively have a significant impact on the purchase of the first and the second type of commodities.

Accordingly, the following measures can be taken to increase the effective consumption of the two types of commodities, and facilitate the construction of an ecological consumption pattern.

First, enhance the publicity on ecological consumption. To intensify people's knowledge on ecological consumption is an important way to facilitate the construction of an ecological consumption pattern. Government departments should beef up their publicity on ecological consumption through lectures, training, bulletins, newspapers, radio and the Internet to help people better understand ecological consumption and improve the level of ecological consumption.

Second, regulate the certification and issuance of environmental labels that serve as important references for the judgment of ecologically- and environmentally-friendly commodities. However, driven by the huge potential economic interests, some enterprises have started to forge environmentally labeled products in such a clandestine manner that not only ordinary consumers are not able to distinguish them, some dealers are also tricked. Such deceptive forgery severely disrupts the market order. The certification committee for environmental labeling should intensify the crackdown on enterprises that forge environmentally labeled products, block the production and sales of faked environmentally labeled products from the source and regulate the market of ecologically- and environmentally-friendly commodities so that consumers can rest assured when purchasing environmentally labeled commodities.

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