Chapter 17
Principles and Application of Sustainable Development

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Abstract At present, sustainable development has become the consensus of governments and the people around the world, and has come from concept to practice. However, it involves the reform of population, resources, environment, production, technology, institutions, and concept. In order to achieve this goal, the road is long and full of hardships in the future. Especially for China, which is a country confronted with an enormous population, a serious shortage of resources per capita, high pressure on employment, outstanding ecological and environmental problems, and the promotion of regional sustainable development has important practical significance. To promote sustainable development, first we need to choose an index that can fully reflect regional natural, economical and social characteristics from the perspective of system, then follow certain principles to establish evaluation indicator or indicator system to evaluate the sustainable development. Single index or multi-index evaluation method can be used for the evaluation of sustainable development. Eco-compensation aims at the conservation and sustainable use of ecosystem services; it is an institutional arrangement that regulates the relationship between different stakeholders using economic method and an important means to realize sustainable development. In China, the theory and practice of eco-compensation has experienced the following stage in turn: groping spontaneously, theoretical research, and combining theory and practice. On the whole, the

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goal of realizing global sustainable development reflects the coordination between human and nature, and between different individuals. Coordination between human and nature provides guarantee for sustainable development, and guarantee of harmonious relations between different individuals reflect the rationality and orderly organization of sustainable development. Implementing the strategy of sustainable development in China, is not only an inevitable choice in the long term, but an inevitable conclusion to improve and promote their development ability in the contrast with countries all over the world.

Keywords Sustainable development · Ecological footprint · Biocapacity · Ecological deficit · Urbanization · Eco-compensation

1 Methods and Indicator Systems

As the global economy continues to grow rapidly, a series of crises have appeared such as overpopulation, shortage of resources, ecological destruction, and pollution. Therefore, it has become the common choice of humankind to consider changing the traditional mode of development, so as to pursue sustainable development. The grim reality and upcoming problems tell us that it is important to promote regional sustainable development for China, and it has become a key issue in current research to build a sustainable development evaluation indicator system to help answer the question, whether human activities contribute to the goal of sustainable development or not. Selection of evaluation indicators and how to determine weights, thresholds, and the overall discrimination method all present challenges for sustainable development evaluation. Regional sustainable development evaluation seeks to evaluate the sustainability of regional development based on research needs, and to choose indicators from a regional point of view reflecting natural, economic, and social characteristics, while building an evaluation indicator system using appropriate mathematical methods.

This study describes research progress toward sustainable development evaluation, both domestic and abroad; analyses several important regional sustainable development evaluation indicators; builds a sustainable development evaluation indicator system for China; notes some problems in the current evaluation of regional sustainable development; and makes proposals for the future of sustainable development evaluation.

2 Application of Ecological Footprint in the Evaluation of Regional Sustainable Development

2.1 Introduction

The biologically productive area was used in the ecological footprint method to measure the demand and impact of human activities on the natural capital (Wackernagel and Rees 1996), and further judge whether the impact is within the scope of the regional biocapacity. In this method, land use was used as a limiting factor to provide us the information of human dependence on nature. Because it has rich connotation of the concept, simple method and vivid expression of the results, it is comprehensive, comparable, and easily understood and accepted. Ecological footprint is taken as a powerful indicator for assessing the regional sustainability. In the twenty-first century, it is a big challenge facing China's sustainable development to improve biocapacity, reduce ecological footprint, and maintain an acceptable eco-environment. In this paper, we used the ecological footprint method to evaluate ecological footprint, biocapacity, and ecological deficit of China from 1980 to 2005.

2.2 Ecological Footprint and Biocapacity in China

2.2.1 Changes in Ecological Footprint

From 1980 to 2005, the consumption of ecosystem services was multiply increased in China, and the ecological footprint per capita increased from 0.98 to 2.17 ghm^2, with the average annual exponential growth rate of 3.2 %, which is three times the world level over the same period. With the strong growth momentum of ecological footprint, the gap between per capita ecological footprint of China and the whole world was reduced by 55 %. It reaches 0.5 ghm^2 in 2005. With the same trend, per capita ecological footprint of China will reach the world average in 2015 or so.

Table 1 shows the components and their changes of per capita ecological footprint of China. We can see that the land used for CO_2 absorption has accounted for more than half of the ecological footprint of China since 1995, and it is becoming the primary element to decide the ecosystem services of China and its growth rate.

Table 1 Components of per capita ecological footprint of China in major years/%

Type	1980	1985	1990	1995	2000	2005
Raw material consumption	56.3	54.6	54.9	48.6	46.4	33.3
Fossil energy consumption	43.7	45.4	45.1	51.4	53.6	63.9
Total	100	100	100	100	100	100

From 1995 to 2000, the total energy consumption of China was kept almost unchanged with an increase rate of 0.6×10^8 tec, and the per capita ecological footprint level of China was also unchanged for the same period. From 2000 to 2005, the total energy consumption of China increased by 63 % and reached 22.5×10^8 tec in 2005, the per capita ecological footprint of China increased about 0.7 ghm^2 over the same period, of which 75 % new ecological footprint come from fossil energy consumption.

With the vast territory of China, the level of socio-economic development and consumption habits for different regions vary greatly, so there are significant regional differences in per capita ecological footprint. From 1980 to 2005, despite the reason that per capita ecological footprint is different for each province, there was an overall increasing trend and it changed significantly in the distribution pattern. At the very beginning, high value per capita ecological footprint was distributed mainly in the northeast China and three municipalities including Beijing, Tianjin, and Shanghai. With the uneven growth of per capita ecological footprint and the expand of high value areas, the per capita ecological footprint currently had the overall pattern of "higher in north and northeast China, medium in east and south China, lower in central, southwest and northwest China".

2.2.2 Changes in Biocapacity

From 1980 to 2005, the total biocapacity of China increased 1.5 times, varying from 5.8 × 108 to 15 × 108 ghm^2. The per capita biocapacity was doubled, varying from 0.59 to 1.15 ghm^2, however, the per capita biocapacity of the world over the same period was shrinking. China is still a country with low biological capacity, and its per capita biocapacity is only half of the world average. China supports nearly 1/4 of the world's population with only 1/11 of the world's farmland. This reality determines that the per capita biocapacity will still be relatively low in the future.

With the uneven distribution of biological resources and productivity, per capita biocapacity is greatly different for different provinces. Table 2 shows that the distribution range of per capita biocapacity for different provinces changed from 0.17–8.25 ghm^2 to 0.32–7.06 ghm^2 gradually from 1980 to 2005, with the highest value in Tibet and lowest value in Tianjin and Shanghai.

2.2.3 Changes in Ecological Deficit

The natural space for per capita biocapacity is relatively low in China. The contradiction between the supply and demand of ecosystem services is very prominent since it is necessary not only to protect the life of the new population, but also to meet the economic development and improve people's welfare. Table 3 showed

Table 2 Change of per capita ecological service of China in different province/ghm2

	11980			11990			1995			2000			2005		
	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES
Beijing	2.2	0.2	−2.0	2.3	0.4	−1.9	2.9	0.4	−2.6	3.3	0.3	−3.0	3.2	0.4	−2.8
Tianjin	1.7	0.2	−1.6	2.2	0.3	−1.9	2.5	0.4	−2.1	2.4	0.5	−2.0	3.4	0.7	−2.7
Hebei	0.9	0.4	−0.6	1.2	0.5	−0.7	1.4	0.7	−0.8	1.5	0.7	−0.8	2.6	1.0	−1.7
Shanxi	1.5	0.5	−1.0	1.3	0.6	−0.8	1.7	0.6	−1.2	1.6	0.5	−1.1	3.1	0.5	−2.6
Neimeng	1.1	3.1	2.1	1.6	2.4	0.8	1.5	2.4	0.8	1.8	2.1	0.4	3.9	3.3	−0.6
Liaoning	1.9	0.6	−1.3	2.1	0.8	−1.3	2.3	1.1	−1.2	2.2	1.3	−0.9	3.3	1.8	−1.5
Jilin	1.3	0.7	−0.6	1.8	1.0	−0.8	1.9	1.0	−0.9	1.6	0.9	−0.7	2.4	1.3	−1.1
Heilongjiang	1.3	1.2	−0.2	1.7	1.4	−0.3	1.9	1.5	−0.4	1.8	1.4	−0.4	2.5	1.6	−0.9
Shanghai	2.0	0.3	−1.6	2.9	0.4	−2.5	3.1	0.4	−2.7	3.0	0.3	−2.7	4.0	0.3	−3.6
Jiangsu	1.0	0.3	−0.6	1.2	0.5	−0.6	1.5	0.7	−0.8	1.5	0.8	−0.7	2.2	1.0	−1.2
Zhejiang	1.0	0.7	−0.4	1.4	0.8	−0.6	1.9	1.3	−0.7	2.0	1.4	−0.6	2.6	1.5	−1.1
Anhui	0.8	0.3	−0.5	0.9	0.5	−0.4	1.2	0.6	−0.6	1.2	0.8	−0.4	1.5	0.9	−0.6
Fujian	0.7	0.8	0.2	1.5	1.1	−0.4	1.7	1.5	−0.2	1.3	2.1	0.8	2.1	2.4	0.4
Jiangxi	0.7	0.6	−0.1	1.2	0.7	−0.5	1.2	0.8	−0.3	1.0	0.8	−0.2	1.5	1.0	−0.5
Shandong	0.8	0.4	−0.4	1.0	0.7	−0.4	1.2	1.1	−0.1	1.2	1.4	0.2	2.3	1.6	−0.7
Henan	0.7	0.3	−0.4	0.8	0.4	−0.4	0.9	0.5	−0.3	1.0	0.6	−0.3	1.6	0.8	−0.8
Hubei	1.0	0.4	−0.6	1.2	0.6	−0.6	1.3	0.8	−0.5	1.5	0.9	−0.6	2.0	1.2	−0.8
Hunan	1.2	0.5	−0.7	1.5	0.6	−0.9	1.5	0.7	−0.9	1.3	0.7	−0.6	2.0	0.9	−1.1
Guangdong	0.9	0.6	−0.4	1.1	0.9	−0.2	1.7	1.0	−0.7	1.7	1.0	−0.6	2.2	1.2	−1.1
Guangxi	0.8	0.7	−0.1	1.1	0.7	−0.4	1.1	0.9	−0.2	1.2	1.2	0.0	2.0	1.4	−0.6
Hainan										1.5	1.6	0.1	1.6	2.7	1.1
Chongqing										1.6	0.4	−1.2	2.2	0.6	−1.6
Sichuan	1.0	0.4	−0.5	1.1	0.6	−0.5	1.3	0.6	−0.6	1.2	0.7	−0.4	1.6	0.8	−0.8

(continued)

Table 2 (continued)

	11980			11990			1995			2000			2005		
	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES	TEF	BC	ED/ES
Guizhou	0.9	0.5	−0.4	1.4	0.5	−0.9	1.2	0.5	−0.7	1.6	0.5	−1.1	2.3	0.5	−1.8
Yunnan	0.9	1.2	0.2	1.5	1.1	−0.4	1.5	1.0	−0.5	1.3	0.9	−0.4	1.8	1.0	−0.7
Xizang	1.1	8.3	7.1	1.4	7.8	6.4	1.3	7.3	5.9	1.7	6.4	4.7	2.3	7.1	4.7
Shaanxi	0.8	0.7	−0.1	1.2	0.7	−0.5	1.2	0.7	−0.5	1.1	0.6	−0.5	1.5	0.7	−0.8
Gansu	0.9	0.6	−0.3	1.2	0.7	−0.5	1.3	0.7	−0.6	1.4	0.6	−0.8	1.4	0.7	−0.7
Qinghai	1.1	1.6	0.5	1.6	1.5	−0.1	2.2	1.6	−0.6	2.1	1.3	−0.7	2.2	1.8	−0.5
Ningxia	1.0	0.4	−0.6	1.5	0.7	−0.9	1.5	0.7	−0.8	1.7	0.8	−0.9	3.2	1.1	−2.1
Xinjiang	1.7	0.7	−1.0	2.0	1.2	−0.8	2.0	1.4	−0.6	2.0	1.4	−0.6	2.1	1.9	−0.2

Note: Hainan data was included into Guangdong and Chongqing data was included into Sichuan before 2000; Calculation for ecological footprint of energy used production area as standard; *TEF* refers to total ecological footprint; *BC* refers to biocapacity; *ED* refers to ecological deficit; *ES* refers to ecological surplus; Due to the limited page space, the data of 1985 was not listed in the table

Table 3 Change of per capita ecological deficit of China/ghm^2

Type	1980	1985	1990	1995	2000	2005
Raw material consumption	0.09	0.05	0.02	0.14	0.27	0.44
Fossil energy consumption	−0.30	−0.38	−0.54	−0.76	−0.79	−1.46
Total	−0.39	−0.32	−0.52	−0.61	−0.52	−1.02

Note: Ecological deficit of fossil energy consumption = (biocapacity of woodland-ecological footprint of woodland)-ecological footprint of fossil energy consumption

that the per capita ecological deficit increased from 0.39 ghm^2 in 1980 to 1.02 ghm^2 in 2005. The natural occurrence constraint of land resources makes China to face more serious ecological deficit problems than the world average. As the world's engine of economic growth, China is in a period of rapid amplification of energy consumption, the growing trend of the ecological deficit will last for the coming period.

Every province in China has faced contradiction between supply and demand of ecosystem services. From 1980 to 2005, more than 85 % provinces has expanding ecological deficit. In 2005, only Hainan, Fujian, and Xizang have ecological surplus in China, and more than 40 % provinces need twice the biologically productive area to balance the demand of ecosystem services. A study has divided these provinces into three groups. Group A includes four municipalities (Beijing, Tianjin, Shanghai, and Chongqing). Group B includes four economically backward western provinces (Guizhou, Ningxia, Sichuan, and Shaanxi). Group C includes four populated eastern provinces (Hebei, Jiangsu, Henan, and Hunan).

The main reasons for the formation of ecological deficit differ for different groups. The reason for group A and group C is the conflict between development scale and resource constraints, while the reason for group B is both the fragile eco-environments and the deficient economic development capacity and more than 40 % provinces need twice the biologically productive area to balance the demand of ecosystem services in 2005. Compared with 1980, the ratio of biocapacity to ecological footprint of 11 provinces was declined, indicating that the gap between ecological supply and demand might widen, but the relative conflict eased.

2.3 Conclusion and Discussion

Since ecosystem service is dependent on area, the consumption of ecosystem services by regional socio-economic metabolism and its satisfaction can be measured by three indicators, including ecological footprint, biocapacity, and ecological deficit. Studies have shown that due to the increasing demand of socio-economic metabolism on ecosystem services, from 1980 to 2005, the consumption of

ecosystem services is more than double in China, and the per capita ecological footprint increased from 0.98 to 2.17 ghm^2. At the same time, since the biological productivity was improved, the per capita biocapacity doubled from 0.59 to 1.15 ghm^2. However, due to the rapid growth in fossil energy consumption, per capita ecological deficit continued to expand and reached 1.02 ghm^2 in 2005. The ecological footprint has exceeded 89 % of the biocapacity. At the provincial level, more than 85 % provinces are in ecological deficit status, and only Hainan, Fujian, and Tibet have ecological surplus. The ecological debts in most provinces of China are soft in nature, caused mainly by the contradictions between supply and demand of ecosystem services in time, space, and structure. This kind of debt can be alleviated by way of cross-trade and advance occupation. Same as most of the world countries and regions, the main way for China to deal with the ecological deficit is also to occupy the current and future global commons, which is an inevitable result of external diseconomies of development. For a long period of time in the future, China will face more severe ecological deficit than the world average. This means that we are increasingly overdraft future ecological capital to maintain existing lifestyles and economic growth, which will cause the ecosystem degradation and collapse.

3 Interactive Coercing Effects Between Urbanization and Eco-environment

3.1 Introduction

An extremely complex interaction exists between urbanization and eco-environment. How to harmonize their relationship has become an important issue that holds the attention of academic circles and governmental departments in China. At the same time, it has also become a global strategic issue. With the rapid urbanization throughout the world, urbanization has become an actual or potential threat to the surrounding eco-environment. All kinds of conflicts and threats have come forth between urbanization process and eco-environmental protection (Fang et al. 2008). From the view of national strategic demands, how to harmonize the relationship between urbanization and eco-environment has become an important topic for national development plan in China. It is of great importance to choose a healthy urbanization mode which can match the urbanization speed with the eco-environmental protection in China, so as to accelerate the process of regional industrialization and construct an ecological industrial structure. It can also help to build resource-saving and environment-friendly cities and eco-cities.

3.2 *Interactive Coercing Effects Between Urbanization Process and Eco-environment*

3.2.1 Basic Laws and Evaluative Types of the Interactive Coercion Between Urbanization and Eco-environment

The interaction between urbanization and eco-environment is extremely complex. It manifests as three kinds of interact, interactive coercion, interactive promotion and coupling symbiosis (Fang 2004). In general, the interactive coupling and coercing system of urbanization and eco-environment should follow six basic laws, i.e., the coupling fission law, the dynamic hierarchy law, the stochastic fluctuation law, the nonlinear synergetic law, the threshold value law, and the forewarning law (Fang et al. 2006). The six basic laws have important theoretical guiding significance to reveal the interactive coercing and coupling relationship between urbanization and eco-environment.

The interactive coupling and coercing relationship between urbanization and eco-environment may be various in different areas with different eco-environmental backgrounds or urbanization modes. In general, the evolutive types of the interactive coercion between urbanization and eco-environment can be classified into nine basic coupling types, i.e., the rudimentary coordinating type, the ecological dominated type, the synchro coordinating type, the urbanization lagging type, the stepwise break-in type, the urbanization exorbitant type, the fragile ecological type, the rudimentary break-in type, and the unsustainable type (Qiao et al. 2006).

3.2.2 The Double-Exponential Function and Curve for the Evolutive Track of the Interaction Between Urbanization and Eco-environment

Based on the mathematic model on urbanization, economic development and eco-environmental change, it can be deduced that the coupling relationship between urbanization and eco-environment is a double-exponential function (Huang and Fang 2003) as

$$z = m - n[10^{\frac{y-b}{a}} - p]^2$$

where z is the degree of eco-environmental deterioration, y is the urbanization level, and m, n, a, b, p are undetermined parameters.

When $y < \text{alg}P + b$, the eco-environment will deteriorate gradually with the increase of the urbanization level.

When $y = \text{alg}P + b$, the degree of eco-environmental deterioration will reach the maximum value m.

When $y > \text{alg}P + b$, the eco-environment will be improved gradually with the increase of the urbanization level.

The double-exponential function relationship indicates that as urbanization progresses the ecological pressure will raise at first and then decline. In other words, eco-environmental deterioration and pollution may appear due to urbanization at first. However, such phenomena will diminish predictably with further urbanization. This is a common rule and a general tendency to the interaction between urbanization and eco-environment.

First, a logarithmic curve and an environmental Kuznets curve (EKC) are put into the first and third quadrants of the same coordinate system, respectively. The former represents urbanization changing with economic development, while the latter represents eco-environment changing with economic development. Next, horizontal and vertical lines are drawn out from the two curves in the first and third quadrants to the second quadrant. Finally, a curve in the second quadrant is formed, which describes the coupling and coercing relationship between urbanization and eco-environment. This curve is divided into two parts by the middle inflection point. The two parts are both exponential curves. The front part (below the middle inflection point) is a monotonically increasing curve. The latter is a monotonically decreasing curve. Prior to the inflection point, the degree of eco-environmental deterioration increases with the increase of the urbanization level. After the inflection point, the degree of eco-environmental deterioration decreases. Combined with a mathematical model, it may be determined that the urbanization level at the inflection point is $y = \text{alg}P + b$.

3.2.3 Basic Stages of the Interactive Coercion Between Urbanization and Eco-environment

According to the development stages and the dynamic mechanisms of urbanization, as well as changes of the interactive coercing relationship between urbanization and eco-environment, the interactive coercing process of urbanization and eco-environment can be divided into five basic stages, namely low-grade coordinating stage, antagonistic stage, break-in stage, ameliorative stage and high-grade coordinating stage (Huang and Fang 2003; Qiao and Fang 2005; Qiao et al. 2005). When the urbanization process steps into the mature stage (urbanization level is higher than 70 %), the destroyed eco-environment will be recovered step by step, and the eco-pressure will decrease to the minimum and remain unchanged. The conflict between urbanization and eco-environment will be eliminated. The urbanization system and the eco-environmental system will coordinate with each other.

3.3 Conclusions and Discussion

(i) An extremely complex, interactive coupling, and coercive relationship exist between urbanization and eco-environment. This kind of relationship can be

described by a double-exponential function or curve deduced by a power function and an exponential function. It can be divided into five basic stages, namely low-grade coordinating stage, antagonistic stage, break-in stage, ameliorative stage, and high-grade coordinating stage.

(ii) The urbanization process mainly follows the human law while the eco-environmental change mainly follows the natural law. Their relationship is extremely complex and nonlinear. Restricted by some conditions, we tentatively summarize the basic theory and method on the interactive coupling and coercing relationship between urbanization and eco-environment. However, how can we find the middle inflection point for the double-exponential curve of interactive coercing relationship between urbanization and eco-environment? How can we make the urbanization circle (or system) and the eco-environmental circle (or system) maintain the best distance and keep a dynamic balance (Wang 1993)? It is a hard question that we are querying all the time. It is also an important theoretical orientation for our further study in the future.

(iii) From the view of national strategic demands, how to practice the moderate urbanization mode, the eco-urbanization mode, the environment-friendly urbanization mode, the resource- saving mode, and the healthy urbanization mode, how to construct eco-cities, resource-saving cities, environment-friendly cities, and healthy cities (Xiao et al. 2002), how to step into a healthy urbanization road adapting to the eco-environmental capacity, are all important practical orientations for our further study in the future.

4 Theoretical Researches and Practices of Ecological Compensation in China

4.1 Theoretical Researches of Ecological Compensation in China

Looking back to the history of ecological compensation researches in China, the features are distinctive by stages, coincided with specific historic and practical needs. In China, ecological compensation researches have been dated back to the 1980s' discussions of ecological compensation in ecological senses and exploration of ecological compensation in economical senses (Zhang 1987). After the United Nation Conference on the Human Environment, ecological compensation researches have entered into a phase of active theoretical discussions on the basis of "damager pays" principle. With the practices of ecological protection programs and the contradictions between ecological protection and economic development, ecological compensation researches have paced into a phase of theoretical and practical discussions expanding to "beneficiary pays" principle. Connotation, standard, and theoretical basis are the key scientific issues in ecological compensation researches. Connotations of ecological compensation have goes from ecological senses through

economical senses to multidisciplinary senses. It is critical to clarify relationships among the ecological compensation fee, environmental and resource fee for its precise positioning in Chinese policy. Ecosystem service and externality theory is the main theoretical basis for ecological compensation. While there is disparity in benefit compensation or value compensation for ecosystem services, it is more at agreement for externality compensation of environmental economics. The standard of ecological compensation is mainly determined by monetary value of ecosystem services, cost or compromise based on analysis of supply and demand. These scientific problems are decisive for the effectiveness and efficiency to put ecological compensation into practice. So, it is in urgent need to do some researches from the angle of theoretical renovations and practical need of different regions in China.

4.2 Practices in Ecological Compensation in China

The practices of ecological compensation in China are dated back to the 1970s in the twentieth century, when 30 % ticket sales of Qingcheng Mountain were used for the conservation of forests in Chengdu of Sichuan province (Feng et al. 2009). Then, the practices in forest and mining areas became the hot spots all over the country. In Yunnan province, 0.3 yuan/ton Ming Phosphate was used as the recovery fee of local environmental damages from the year 1983. The State Council approved the energy base in Inner Mongolia Baotou and contiguous areas to levy eco-environmental fee. Then, 145 counties of 14 provinces accelerate the pilot practices. Before the year 1998, the practices of ecological compensation have focused on the environmental damage pay. Afterwards, the ecological protection and construction are given more priority due to the flood in Yangtze river, Songhua River, and Nen River in 1998, and dust storm in 2001. The central government launched six ecological projects, including natural forest protection project, three-north shelterbelt protection project, Yangtze river shelterbelt protection project, reforestation project, reverting farmland to forest and grassland project, antidesertification projects in Beijing area, wildlife conservation project, natural reserve construction project, and key areas of fast growing timber base construction project. In 1998, China's new forest law defines the legal regime of forest ecological benefit compensation fund.

Entering the twenty-first century, the exchanges and cooperation in the international area are strengthened. Governments at all levels, especially development and reform commission and environmental protection system are the key forces to promote communications internationally and summarize international experience, including "Proposal for China to promote ecological compensation practices and international cooperation."

The central government put great efforts to promote the practice of ecological compensation. Programmatic document clearly put forward the ecological compensation requirements such as the report at 17th/18th Party Congress. Ecological

compensation has been the important content in environmental protection, accelerating pilot ecological compensation. The legal and policy support of ecological compensation has also been strengthened. Ecological Compensation Ordinance has been included in the legislation plan from 2010.

Table 4 Overall frameworks of ecological compensation in China

	Types of compensation	Contents of compensation	Ways of compensation
International compensation	Worldwide/regional/international ecological and environmental problems	Worldwide forest and biodiversity protection, pollutions transferring, greenhouse gas emission, transboundary rivers, etc	Global purchase under multilateral agreements
	Ecosystem compensation	Forest, grassland, wetland, ocean, farmland, etc., ecosystem services compensation	State (public)compensation by financial transfer payment, ecological compensation fund, market transaction, and participation of businesses and individuals
National compensation	Watershed compensation	Watershed Compensation across provincial borders, Watershed compensation in local administrative districts	Financial transfer payment, local government coordination, market transaction
	Regional compensation	Compensation for the eastern region of the western region	Financial transfer payment, local government coordination, market transaction
	Resources development compensation	Mining development, land reclamation, vegetation restoration, etc	Beneficiary payment, damage payment, development payment

The local governments have accelerated the pilot ecological compensation, mainly in watershed areas and regional areas, including Fujian, Shandong, Zhejiang, Fujian, Henan, and Hebei provinces.

Under the active promotion of government, the market transaction of ecological compensation has important progress. By actively improving the management mechanism of market transactions, setting up carbon trading platform, promoting carbon trading pilot projects, and by other means the carbon trading market in China has been more mature. In 2003, State Forestry Administration established the office of carbon sequestration, energy offices, climate office and other agencies, and relevant policies and regulations of forest carbon management has been put forward. In 2010, China Green Carbon Foundation was incorporated, which became the first national public foundation aiming to increase carbon sequestration and countering climate change. Companies can buy carbon sequestration through donation for afforestation. In 2008, the first batch of six carbon sink afforestation projects was implemented. In 2011, China Green Carbon Foundation and the East China Forestry Exchange launched national rreen carbon trading pilot ceremony. Ten companies signed the first batch of 148,000 tons to subscribe forestry carbon sinks, the price is 18 Yuan per ton, which is China's first forestry carbon sequestration transaction under standardized operation. In 2012, Beijing, Shanghai, Chongqing, Tianjin, Guangdong, Hubei, and Shenzhen are approved to start carbon emissions trading pilot in order to gradually establish a domestic carbon emissions trading market, with a lower cost, to achieve 2020 Chinese action to control greenhouse gas emission targets (Table 4).

4.3 Proposals for Improvement of the Theoretical Researches and Practices of Ecological Compensation in China

Theoretical researches of ecological compensation in China are ecological and environmental protection-oriented to address the relationship between environmental protection and economic benefits for the target distortions. A large number of academic scholars hold for a long-time discussion on the domestic ecological compensation policy formulation and improvement of laws and regulations, which have played an important role in guiding. But theory and practice still exists disjointed. Theory is behind the practice and exploration, Ecological protection in practice, still is in the absence of structural policies, especially lack of specific ecological compensation policies and implementation guidelines. Not only the ecological protection and construction advancing toward a higher level face great difficulties, but also affect the harmony between regions and between stakeholders.

So, we propose to improve the following aspects:

(i) Unifying ecological compensation connotation and gradually improve the overall framework of ecological compensation;
(ii) Conducting partition guidance and classification implementation;
(iii) Establishing sound fiscal policies of ecological compensation system, and actively exploring financing mechanisms and multi-channel;
(iv) Handling the relationship of ecological compensation policies, including the relationship between central and local governments, the relationship between government and the market, the relationship between financial transferring and self-reliance, and the relationship between the new account and the old account;
(v) Creating ecological compensation legal environment and improving the management mechanism;
(vi) Strengthening scientific research and pilot project of ecological compensation.

5 River Basin Eco-compensation Progress in China

China's river basin eco-compensation has strong policy basis and rich practice progress. In this chapter, it sorts China's eco-compensation policies, laws, and regulations, and summarizes China's exploitation of typical cases and main models in river basin eco-compensation, which addressed current status of China's river basin eco-compensation in aspects of policy and regulation basis and practice basis.

5.1 Introduction

Since the end of 1990s, the Chinese government began to pay close attention to research on eco-compensation in river basin; with the twenty-first century coming, the quantitative research on eco-compensation in river basin reached a peak. Now the pattern has been formed with a variety of compensation types and modes coexist after over 10 years of evolution. The eco-compensation has been really focused by the whole society of China after the "11th Five-Year Plan"; the NPC and the CPPCC members put forward many suggestions and bills every year during "two sessions", the reports on government work also highly valued it. Many local governments have started the positive exploration on eco-compensation mechanism, and carried out the pilots for river basin eco-compensation mechanism; some provinces have established the river basin eco-compensation mechanism throughout the province. The river basin eco-compensation pilots in China have initially formed a mode suitable for the regional characteristics.

5.2 Chinese River Basin Eco-compensation Progress

5.2.1 Basis of Policies and Regulations

The Related State Policies and Regulations

With worsening river basin environmental pollution and aggravating environmental management since the 1970–1980s, Chinese Government and relevant ministries have successively issued a series of laws and regulations and policy documents, which called for strengthening the river basin environmental protection and increase the related inputs. In recent years, more laws and regulations and policy documents clearly put forward the eco-compensation mechanism, especially since *Decision of the State Council on Implementing the Scientific Outlook on Development and Strengthen Environmental Protection* (State [2005] No. 39) was issued in Dec 2005; the Party Central Committee and the State Council clearly required to establish eco-compensation mechanism in the relevant files for many times, the Ministry of Environmental Protection, the Ministry of Finance (MOF), the National Development and Reform Commission, Ministry of Water Resources, etc., are also actively preparing for study and formulation of eco-compensation policy, and carry out the eco-compensation pilots in river basin.

It is stipulated in the *Water Law of the People's Republic of China,* effective since Oct 2002 that "if the livelihood and production of other units or individuals are caused losses as groundwater declined, exhausted or ground depressed and so on due to the exploited mine or underground engineer, the mining or construction entity shall take remedial measures and compensate for such losses". This kind of loss compensation actually reflects the implications of eco-compensation. In the field of eco-compensation in river basin, Chinese government has carried out some programs, such as the natural forest protection project and returning farmland to forest project, as well as the ecological protection project in three-river source, etc., since the end of last century. These policies implemented at national level, reflect the national emphasis on eco-compensation in the upstream to a certain extent.

In March 2004, the *Several Opinions of the State Council on Further Promoting Development of the Western Region* (State [2004] No. 6) was issued to specify: "to establish the compensation mechanism for ecological construction and environmental protection, and encourage all kinds of investors to participate in the ecological construction and environmental protection."

In April 2005, the *Key Works of the State Council 2005* was released (State [2005] No. 8) to stipulate: "to strengthen management of the mineral resources exploitation, rectify and standardize the order of mineral resources exploitation, improve the compensation mechanism for resources development and utilization and ecological environment restoration."

In June 2005, the *Several Opinions of the State Council on Promoting Sound Development of the Coal Industry* (State [2005] No. 18) was issued to stipulate: "to strengthen the ecological environment and water resources protection, management

of wastes in the mining areas and coal-mining subsidence area according to the principle of 'developer protects, destructor recovers, beneficiary compensates, and polluter pays'; research to establish the compensation mechanism for ecological environment restoration in the mining areas; define management responsibilities of the enterprise and government; increase inputs for the ecological environment control, and gradually make the mining area environment control step into a virtuous cycle. For the historic issues during the environmental management such as mining subsidence caused by original key state-owned coal mines, the special planning shall be prepared to continuously implement the comprehensive management, the central government shall give necessary funds and policy supports, and the local governments at various levels and the coal enterprises shall arrange the supporting fund according to the regulations."

It is provided in the circular of the State Council on *Accomplishing Key Works During Construction of Conservation-Minded Society* (State [2005] No. 21) issued in June 2005: "to research how to establish and improve the resources exploitation and eco-compensation mechanism on the basis of straightening out the existing channels for charges and fund sources."

In July 2005, the Several Opinions of the State Council on *Accelerating the Circular Economy Development* (State [2005] No. 22) was issued to specify: "to positively research how to establish and improve the eco-compensation mechanism for restoration of enterprise ecological environment on the basis of straightening out the existing channels for charges and fund sources."

In December 2005, the Decision of the State Council on *Implementing the Scientific Outlook on Development and Strengthen Environmental Protection* (State [2005] No. 39) was issued to provide: "to improve the eco-compensation policies, and establish eco-compensation mechanism as soon as possible. The eco-compensation factors shall be considered in the central and local fiscal transfer payment, the State and local governments can implement some eco-compensation pilots."

In December 2005, the Several Opinions of the CPC Central Committee and the State Council on *Pushing Forward New Socialist Rural Construction* (Central [2006] No. 1) was issued to specify: "to continuously promote the ecological construction; earnestly implement key ecological projects, such as the returning farmland to forest and natural forest protection; stably improve the policies; cultivate the follow-up industries; consolidate the ecological construction results according to the requirements for construction of environment-friendly society; continuously push forward the return the grazing land to grassland and comprehensive development of mountainous area; establish and improve the eco-compensation mechanism; carry out major pest control, take effective measures to prevent the exotic biological invasion; strengthen the desertification control, and actively implement the comprehensive control project for soil and water erosion for the rocky desertification area and northeast black earth area; establish and perfect the responsibility mechanism of hydro-electric power and mining enterprises for the environmental restoration and control, extract certain funds from the revenue of

hydro-electric power and mineral resources development for the restoration and management of local environment, and prevent water losses and soil erosion."

In March 2006, the *Key Works of the State Council 2006* was issued (State [2006] No. 12) to stipulate that: "the eco-compensation mechanism shall be urgently established."

In March 2006, the *Outline of 11th Five-Year Plan for the National Economic and Social Development* was issued by the National People's Congress to stipulate that: "the eco-compensation mechanism shall be established according to the principle of developer protects and beneficiary compensates."

On April 17, 2006, Premier Wen stressed at the 6th *National Environmental Protection Conference* that "the eco-compensation mechanism shall be established according to the principle of 'developer protects, destructor recovers, beneficiary compensates, and polluter pays'."

In October 2006, the Decision of the Central Committee of the CCP on Major Issues about *Constructing Harmonious Socialistic Society* (Central [2006] No. 19) was issued by the 16th CPC Central Committee at the Six Plenary Session, which provided: "to improve the industrial policy, finance and tax policy, and pricing policy in favor of environmental protection, establish an evaluation system and compensation mechanism for ecological environment, and strengthen the responsibilities of enterprise and the whole society to save resources and protect the environment."

In December 2006, the Several Opinions of the CPC Central Committee and the State Council on *Positively Developing Modern Agriculture and Steadily Pushing Forward New Socialist Rural Construction* (Central [2007] No. 1) was issued to specify: "to continuously push forward the major ecological projects, such as natural forest protection and returning farmland to forest, further improve the relevant policies and consolidate the achievements; start the comprehensive treatment engineering for rocky deserts, continuously implement the coastal shelter forest project; improve the forest eco-compensation fund system; explore to establishment of grassland eco-compensation mechanism; and speed up some projects of returning the grazing land to grassland."

In March 2007, the *Key Works of the State Council 2007* was released (State [2007] No. 8) to stipulate: "to accelerate establishment of eco-compensation mechanism."

In May 2007, the *Work Scheme on Energy Conservation and Emission Reduction* (State [2007] No. 15) was issued by the State Council to specify: "to improve the paid-use system for mineral resources, improve and perfect the eco-compensation mechanism for resources development; and conduct the pilot for trans-basin eco-compensation."

In July 2007, Opinions of the State Council on *Compiling the Planning for National Main Function Regions* (State [2007] No. 21) was released to specify that: "in order to realize the equal access to basic public service, the central and provincial financial transfer payment system shall be improved through mainly increasing the financial transfer payment for public service and eco-compensation of the development-limited and development-prohibited regions; gradually

implement the investment policy according to major function regions and the relevant field, the governmental investment shall mainly support the public service facilities construction, ecological construction and environmental protection in the development-limited and development-prohibited regions; and support the infrastructure construction in the key development areas."

On October 15, 2007, General Secretary, Hu Jintao's report at the 17th National Congress definitely required: "to implement the fiscal and taxation systems conducive to the scientific development, establish and improve the paid-use systems of resources and eco-compensation mechanism."

In November 2007, the *11th Five-Year Plan for National Environmental Protection* was promulgated (State [2007] No. 37) to provide: "to implement the target responsibility system for river basin management and assessment system for water quality at the trans-provincial monitoring section; speed up establishment of eco-compensation mechanism; increase input from various channels; accelerate construction of regulation project; plan development, utilization and protection of river water resources as a whole, distribute water for life, production and ecology as a whole, so as to ensure the ecological runoff of rivers"; "define the range, leading function and development direction of key ecological function reserves, and explore establishing the evaluation index system, management mechanism, performance evaluation mechanism and eco-compensation mechanism for ecological function reserves according to the requirements for development-limited areas"; "accelerate establishment of the earnest money system for mine environment to restore; push forward mine environment management, and promote the ecological restoration for new and old mines and resource-exhausted cities"; "give priority to establish and implement the eco-compensation mechanism in the western regions"; "according to the principle of 'developer protects, destructor recovers, beneficiary compensates, and polluter pays', Three Gorges Reservoir Area, the catchments area for The South-to-North Water Diversion Project, key energy development zones and national nature reserves shall be taken as a breakthrough to expand the pilot, improve the eco-compensation policies and establish the eco-compensation mechanism"; "the finance and tax departments shall formulate the finance and tax policy favorable to environment protection, establish and improve the eco-compensation mechanism, support construction of early warning system for environmental monitoring and supervision system for environmental enforcement."

In December 2007, *Several Opinions of the State Council on Promoting the Sustainable Development of Resource-Based Cities* (Central [2007] No. 38) was issued to specify: "to improve the pricing mechanism for resource products; speed up reform of resource prices, and gradually form a pricing mechanism of resource products which can reflect the scarcity degree of resources, relation between market supply and demand, as well as cost of environmental and ecological restoration; scientifically formulate the financial accounting method for cost of resource products, the resource product cost shall be listed with such expenditures as acquisition of mining right, resources exploitation, environment management, ecological restoration, safety facilities, infrastructure construction and enterprise transformation; improve the eco-compensation system for forest benefit, prevent

exteriorization of the internal cost of enterprise and socialization of private cost"; "combine with establishing the pilot of margin system for mining environmental restoration, research to establish the reserve fund system for sustainable development, the resources enterprises shall be extracted a certain proportion from the pre-tax income as the sustainable development reserve fund which is specially used for environmental restoration and eco-compensation to develop the substitution industry and solve the historic problems and rehabilitative work after the enterprises are closed, etc., the local people's governments at all levels shall strengthen supervision of the reserve fund in accordance with the principle of owned by enterprise, special fund for special purposes, deposit in the special account and regulated by the government".

In March 2008, the *Key Works of the State Council 2008* was released (State [2008] No. 15), which stipulated: "to reform resources tax and fee system, and improve the paid-use system of resources and eco-compensation mechanism."

As a milestone of eco-compensation in river basin, *Law of the People's Republic of China on Prevention and Control of Water Pollution* was amended and passed in 2008 and was implemented on Jun 1, 2008, which first put forward eco-compensation for water environmental protection in the national laws. Article 7 is stipulated that: "the State will establish and improve the eco-compensation mechanism of water environment protection for drinking water source reserves, rivers, lakes and the upstream of reservoirs through the financial transfer payment, etc." Article 4 is provided that: "The governments at or above county level shall incorporated water environment protection in the national plan for economic and social development." "The local governments at or above county level shall take countermeasures or measures to prevent and control water pollution, and be responsible for water environmental quality in their respective administrative regions," and Article 5 is stipulated that: "the State will implement the target responsibility system and evaluation system for water environmental protection, the completion situations of water environmental protection goals shall be brought as a content to evaluate the local governments and the responsible persons."

On July 22, 2008, circular of the State Council *Forwarding Opinions of National Development and Reform Commission on Deepening Reform of Economic System* (General Office [2008] No. 103) was promulgated to stipulate that: "the paid-use system of resources and eco-compensation mechanism is one of the three major mechanisms of resource conservation and environmental protection." The circular requires the MOF, MEP, and NDRC which lead to push forward the pilot work to establish the trans-provincial basin eco-compensation mechanism.

2009 Governmental Work Report pointed that: "to push forward the pricing reform of resource products; continuously deepen the reform of electricity price; gradually improve the pricing mechanism for feed-in electricity price, electricity price of transmission and distribution and sale, timely rationalize the pricing relation between coal and electricity; actively promote water price reform; and gradually increase water price of water conservancy projects for nonagricultural purposes; improve the management and collection system of water resources fee; accelerate establishment and improvement of the paid-use system of mineral

resources and eco-compensation mechanism; and actively carry out pilot for emission trading."

Since 2005, the MEP, MOF, NDRC, and MWR have actively prepared to make eco-compensation policy and implement pilot work for eco-compensation in river basin.

In 2007, the former SEPA (State Environmental Protection Administration) promulgated the *Guidance on Implementation of Eco-Compensation Pilot* (MEP [2007] No. 130) to require the local governments to gradually establish the eco-compensation mechanism in four fields including the nature reserves, the major ecological function areas, exploitation of mineral resources, and water environmental protection; among of them, the basin eco-compensation is one of the key fields of the ecological environment compensation.

In 2008, MEP issued the *Guidance of Ministry of Environmental Protection on Prevention and Handling Trans-Provincial Water Pollution Disputes* (MEP [2008] No. 64) to require that the trans-provincial water pollution disputes shall be prevented from the beginning, and the long-term work mechanism shall be established to prevent and handle the trans-provincial water pollution disputes.

In May 2008, the MEP approved Min River Basin in Fujian province as the first batch of eco-compensation pilot areas.

Since 2008, the MOF has successively issued several transfer payment policies related to eco-compensation, mainly including the *Circular of Ministry of Finance on Issuing 2008 Transfer Payment Fund for Ecological Reserves*, such as three-river source (Financial Budget [2008] No. 495) and the *Measures for Transfer Payments to National Key Ecological Function Areas (Pilot)*, etc.; among them, the former points out that: "according to the current general transfer payment method, now the central finance hereby increases your province (autonomous region, municipality directly under the central government) the local general transfer payments in 2008 through increasing the subsidy coefficient for some counties, etc., all of these funds must be used for natural forest protection project, Qinghai Three-River Source, and Middle route Project of South-To-North Water Diversion, Danjiangkou Reservoir Area and the upstream Counties and Districts."

Since April 2010, the Chinese government launched the legislation work on eco-compensation, the *Regulations on Eco-Compensation* (hereinafter referred to as "Regulations"), which is intensively drafted with leaded by the NDRC at present; Cooperate with drafting of the regulations, NDRC also organized to prepare the *Several Opinions on Establishing and Improving the Eco-Compensation Mechanism* as the prelude of the regulations; The basin eco-compensation is the key field of the regulations, the related research and investigation and subsequent file organization are conducted by the "river basin team" of MEP before drafting the regulations.

By the end of 2010, the MOF and MEP totally allocated RMB 50 million as startup capital to Anhui province for Xin'an River as the first national trans-provincial water environment compensation pilot, which is of great significance to the cross-boundary basin eco-compensation in China.

In 2011, *Outline of 12th Five-Year Plan for National Economic and Social Development* required: "to accelerate establishment of eco-compensation mechanism according to the principle of 'developer protects, and beneficiary compensates'; strengthen the balance transfer payment for key ecological functional areas, research to establish the national special eco-compensation funds; implement the reserve fund system for sustainable development of the resource-based enterprises; encourage, guide and explore implementation of eco-compensation from the downstream to upstream, from development area to the protected area and from the ecological beneficiary area to the ecological protection area; actively explore the market-based eco-compensation mechanism; and speed up implementation of the Regulations."

In 2011, the *12th Five-Year Plan for National Environmental Protection* specified that: "the Central Finance will increase support to the western region, development-prohibited area and development-limited area, and special poverty areas, and improve the provision level for basic public services for environmental protection through general transfer payments and eco-compensation measures."

In 2011, *Opinions of the State Council on Strengthening Key Works during Environmental Protection* (State [2011] No. 35) explicitly provided to speed up establishment of eco-compensation mechanism and national special eco-compensation fund, and expand scope of eco-compensation.

In December 2011, the *7th National Environmental Protection Conference* proposed that: "it shall be adhere to integrate the development with protection, and actively explore new route for the sustainable environmental protection with lower cost, better benefit and less emission."

Related Regulation Documents at Local Level

On local level, the local legislation first defined that the river basin eco-compensation was an eco-compensation measure on rivers within the boundary of Changsha City, Hunan province (trial implementation), issued in February 2012. The measures have defined "river eco-compensation" as: "a public system, aimed at protecting eco-environment, promoting the harmonious development between man and nature, make an overall use of economic means and adjust the economic benefit relation between upstream and downstream of river basin and among water ecological protectors, beneficiaries and destroyers." Some departments, on provincial and municipal level have also successively launched the study and practice of trans-provincial or cross-boundary river basin eco-compensation, effectively pushing forward the establishment of two-way or one-way responsibility mechanism concerning compensation from river basin downstream to water resource and water environment protection of upstream and compensation from upstream to downstream for pollution discharge beyond the standard or environmental liability accident.

Amid the establishment of river basin eco-compensation mechanism, the launch of eco-compensation work has been promoted through river basin eco-compensation

Table 5 Summary of agreement on river basin eco-compensation at local level

Year	Document	Content
2007	The guideline on launching eco-compensation pilot work	Support upstream and downstream areas of river basin to reach environmental cooperation agreement based on water quantity distribution and water quality control
2007	Management measures on special fund for water environment protection of min river basin and Jiulong River Basin	"Encourage the cities (districts) in upstream and downstream areas of river basin to protect basin water environment, improve water quality through consultation, signature of agreement and other approaches, based on the assessment requirement of meeting the ecological water quantity demand, specify the compensation liabilities and control tasks of both parties, ensure the capital to yield return, gradually establish and improve eco-compensation mechanism, give reward and punishment to the cities and counties in upstream and downstream of "two river" basins according to water environment quality status of "two river" basins and regional border sections"
2011	Framework agreement on city alliance for Wei river basin environmental protection	The people's government of two cities and one district in Shaanxi and Gansu province established a basin eco-compensation mechanism, built water quality monitoring network at provincial and municipal boundaries, set leaving-the-boundary water quality objective for trans-provincial or tans-municipal boundaries, make assessment and give compensation according to water quality objective. The interim assessment factors for sections leaving the boundary include chemical oxygen demand (COD) and ammonia nitrogen. The leaving-the-boundary water quality assessment is based on monitoring result jointly recognized by Shaanxi Provincial Department of Environmental Protection and Gansu Provincial Department of Environmental Protection. Eco-compensation fund is specially used for pollution control projects, water source ecological construction projects and water quality monitoring capacity improvement projects in Wei River Basin and is not

(continued)

Table 5 (continued)

Year	Document	Content
		allowed to be used in balancing the financial power
2011	Management regulation on Taihu Lake Basin	Where the upstream areas have not finished key water pollutant discharge, total amount reduction and control plan and the administrative region border section water quality fails to meet the stage water quality objective, they shall give compensation to the downstream areas; where the upstream areas have finished key water pollutant discharge total amount reduction and control plan and the administrative region border section water quality meets the stage water quality objective, the downstream areas shall give compensation to the upstream areas. The compensation will be paid through financial transfer payment mode or other modes agreed by local governments through consultation. The specific approaches shall be formulated by competent departments in charge of finance and environmental protection under the State Council together with people's governments of two provinces and one city The issue of the document is an important milestone of basin legislation, which will inevitably produce tremendous promotion effect and far-reaching historical influence
2012	Protection regulation on Xiangjiang River, Hunan Province	Establish and improve a handover responsibility and compensation mechanism for administrative region border section water quality in upstream and downstream water body of Xiangjiang River Basin. Where the upstream areas have not finished key water pollutant discharge total amount reduction and control plan and the administrative region border section water quality fails to meet the stage water quality objective, they shall give compensation to the downstream areas; where the upstream areas have finished key water pollutant discharge total amount reduction and control plan and the administrative region border section water quality meets the stage water

(continued)

Table 5 (continued)

Year	Document	Content
		quality objective, the downstream areas shall give compensation to the upstream areas. The compensation will be paid through financial transfer payment mode or other modes agreed by local governments through consultation
2012	Regulation on water pollution prevention and control of Chaohu Lake Basin (revised draft)	Where the upstream areas have not finished key water pollutant discharge total amount reduction and control plan and the administrative region border section water quality fails to meet the stage water quality objective, they shall give compensation to the downstream areas; where the upstream areas have finished key water pollutant discharge total amount reduction and control plan and the administrative region border section water quality meets the stage water quality objective, the downstream areas shall give compensation to the upstream areas

agreement signed between local governments. Since it does not involve any change of existing administrative management system, it is less difficult. Besides, it is subject to timely adjustment according to implementation result, therefore, it has gained the support of SEPA, especially water environment eco-compensation pilot for Xin'an River basin in 2011, which has offered a good pilot and exploration specimen for award and punishment to water environment in Chinese trans-provincial major river basins and building a sharing protective mechanism (Table 5).

To sum up, two-way type eco-compensation of upstream and downstream based on river basin cross-boundary section water quality assessment, generally practiced in various regions at present is actually a comprehensive system integrating eco-compensation and pollution indemnity, which can be called as a two-way mechanism of compensation by polluters and indemnification to beneficiaries or penalty for water quality beyond the standard and reward compensation for water quality up to the standard. Under this system, downstream will give compensation to the upstream when the upstream has reached the prescribed water quality and quantity objective according to "environment liability agreement" concluded by upstream and downstream or river basin water quality objective defined in river basin environmental protection plan, where the upstream fails to meet the prescribed water quality and quantity objective, or cause water pollution accident to the downstream; the upstream shall give its compensation or indemnification to the downstream conversely. Among others, indemnification shall be compensation to downstream areas made by upstream areas for the loss caused by pollution

beyond the standard. The compensation amount is related to category, concentration, and water quantity of pollutant beyond the standard and duration exceeding the standard. Compensation method by agreement shall proceed from the "fair" angle; the eco-compensation criterion shall be determined among stakeholders in a fair and reasonable way through consultation and coordination in a bid to achieve a "win-win" compensation result to both parties of interest. Therefore, it is necessary to intensify water quality liability mechanism of river basin cross-boundary sections, highlight "common but distinguishing responsibilities" assumed by river basin governments to water quality in outbound sections. As a matter of fact, there are a lot of highlights with reform of basic level, deserving our attention. Eastern region has especially condition and liability to implement and test in reform. Regulation on eco-compensation in Yangtze River delta is also being drafted.

5.2.2 Practice Progress

Cases of China's Eco-compensation Practices in River Basins

Presently, many local governments have begun to boldly explore river basin eco-compensation mechanism which has been already established province-wide in some provinces. So far, nearly 20 provinces have issued and implemented some river basin eco-compensation policies, of which contents cover its principles, objectives, criterion, organization, and implementation. Such policies have made certain effect in the relevant river basins, promoting management and water quality improvement in such river basins. The eco-compensation in China has initially formed its mode suitable for local characteristics, which can be divided into two types, namely economic compensation for water source protection and cross-boundary eco-compensation and pollution indemnity.

(I) **Economic Compensation Mode for Water Source Protection**
The economic compensation for water source protection is a kind of institutional arrangement with priority of economic incentives to encourage ecological protection and construction of water source, to curb ecological destruction, to adjust the distribution relations of ecological and economic benefits among the stakeholders, and to promote the regional fairness and coordinated development, so as to improve the ecological environment, sustain the ecosystem balance, and maintain ecosystem services of water source. In most cases, the economic compensation for drinking water source is a kind of compensation from the developed regions to the underdeveloped regions, in order to compensate them giving up economic development due to protection of the ecological environment. In practice, China's eco-compensation in river basin is mainly realized by means of special funds, development relocation, and the water rights transaction.

- Special fund for eco-compensation mechanism in the Min River Basin in Fujian province

  The Min River is the largest river in Fujian province with an annual runoff of 62.1 billion m^3. It mainly flows through Fuzhou, Nanping and Sanming, with a drainage area about half of the total area of Fujian province. As the mother river of Fujian province, Fujian provincial government set up a special fund for eco-compensation in the Min River basin. From 2005 to 2010, Fuzhou city government from the downstream portion, annually provided RMB 10 million to the upstream Sanming city and Nanping city (RMB 5 million each); and meanwhile, each of Sanming city and Nanping city annually invested RMB 5 million to the Min River basin water treatment. In addition, the provincial environmental protection bureau arranged RMB 15 million to support the special fund for eco-compensation. At the same time, the Provincial Department of Finance and Department of Environmental Protection have formulated *Administration Measures of Special Fund Water Environmental Protection of Min River Basin* to regulate forms and content of eco-compensation.

  The special fund is mainly used in implementation of the projects listed in the *Plan of Water Environmental protection in Min River Basin* approved by the Provincial Finance Department under jurisdiction of Sanming and Nanping as well as the annual treatment program. Focus is on pollution control for livestock and poultry breeding, township waste disposal, water source protection and rural non-point source pollution control, industrial pollution prevention and control, and construction of online monitoring facilities of the pollution sources.

- Special fund for eco-compensation practice in five river source areas in Jiangxi province

  As Jiangxi province is the source area of the Dongjiang River, Jiangxi Provincial Finance Department set up a special fund to establish an eco-compensation mechanism that began in 2008, aimed at rewarding the local counties and cities for their ecological environmental protection of the source areas of "five rivers and one lake" and the Dongjiang River source area with compensation range covering 40 towns. The special fund has been annually increased from RMB 50 million in 2008 to RMB 80 million in 2009 and RMB 103 million in 2010. The reward amount consists of two parts, the first is determined on the basis of area of each protection zone in the source area, accounting for 30 % of the total reward amount; the second part is determined according to effluent water quality of each protection area, accounting for the remaining 70 %.

  The special funds are arranged by each county's financial department as a whole, mainly used for expenditure related to pollution control and ecological protection. The application of funds is subject to random supervision and management by the provincial department of finance and environmental protection bureau. The provincial department of finance and

environmental protection bureau also jointly issued the *Administration Measures of Jiangxi Province for Ecological Environmental protection Reward Fund of "Five Rivers" and Dongjiang River Source Areas* for standard use and management of the funds.

- Mode of water right transaction
  Water right transaction refers to situations when the upstream adopted a series of water-saving measures to make the water amount leaving the border more than the target limit, then the downstream should pay to the upstream for utilization right of this part of water resources, even that part of which the initial water right does not completely use. Water right transaction is essentially to minimize the marginal cost of water resources utilization or maximize value-added benefits with exchange.
  The first water right transaction was initiated in the Jinhuajiang River basin, Zhejiang province. On November 24, 2001, an agreement between Yiwu city and Dongyang city in the midstream of the river basin was initially signed. Dongyang city transferred permanent water rights of an annual 49.999 million m^3 in the Hengjin Reservoir to Yiwu city at a price of RMB 4/m^2 in a one-off deal with the current state of Grade-I drinking water quality guaranteed. Similar cases of water resources trading also exist between Ningxia Hui Autonomous Region and Inner Mongolia Autonomous Region, namely the upstream irrigated areas through water-saving transformation sell the redundant water to the downstream hydropower station.
- Mode of development relocation
  To avoid pollution caused by the industrial development in the upstream and compensate the loss due to limits to development rights, the industrial zone is established at the downstream city, and income tax belongs to the upstream city, which is a specific mode of development relocation.
  A case of development relocation mode was carried out in Jinhua city, Zhejiang province. Pan'an County, under jurisdiction of Jinhua city, is located in the source area of the Jinhua River, and it is an important ecological function area with a backward economy. To support economic development in Pan'an County, the "Jin-Pan Poverty Alleviation Economic and Technology Development Zone" for Pan'an County was set up within the Jinhua Industrial Park at the downstream of the Jinhua River with support in aspects of policy and infrastructure, while all income tax from the development zone belongs to Pan'an County.

(II) **Mode of Cross-Boundary Eco-compensation and Pollution Indemnity**
The cross-boundary eco-compensation and pollution indemnity means, when water resource use or pollution in river basin can be controlled within the corresponding total amount or the assessment criterion of cross-boundary section, if there is not sufficient water yield and environmental capacity to be occupied by other regions, and then the positive externality is produced, the downstream shall compensate the upstream investment for their ecological and

environmental protection costs input to provide water ecosystem services higher than the benchmark. On the contrary, if the negative externality is produced, the upstream shall undertake the downstream additional treatment cost due to pollution surpassing the standard and compensate the downstream corresponding damage, namely certain economic compensation shall be paid to the downstream.

In China, the specific practices of river basin eco-compensation and pollution indemnity is to monitor the administrative cross-boundary section water quality of a river basin, if water quality provided by the upstream meets the target requirements, the downstream areas must provide eco-compensation to the upstream; if not, the upstream must provide pollution indemnity to the downstream.

- Trans-provincial water environment compensation in the Xin'an River Basin

  The Xin'an River originates in Huangshan city, Anhui province and flows through Anhui and Zhejiang provinces with a total area of 11,674 km^2, 53.6 % of its total area is located in Anhui province, only behind that of Yangtze River and Huai River, ranking as the third largest water system in Anhui province. Xin'an River is also an important source of the Qiantang River, the biggest entry river of Zhejiang province. In December 2010, the Xin'an River basin was officially inaugurated for water environment compensation as the first trans-provincial pilot area in China. The MOF allocated RMB 50 million as the initial capital for pilot eco-compensation in the Xin'an River in Huangshan city, Anhui province. In October 2011, MOF and MEP jointly issued the *Implementation Plan of Water Environment Compensation in Xin'an River Basin*, which specifically provided the guiding ideology, basic principles and specific measures, etc., for the implementation of eco-compensation in the Xin'an River basin. Specific measures of the eco-compensation in the Xin'an River Basin are as follow:

  The reference of eco-compensation is the water pollution composite index of the trans-provincial monitoring site—the Jiekou site. The composite index is determined on the basis of four indices: potassium permanganate index, ammonia and nitrogen, total nitrogen, and total phosphorus confirmation. The central finance arranged RMB 300 million as a compensation fund. When Anhui province supplies water with water quality better than the basic standard, it will receive compensation of RMB 100 million from Zhejiang province, and otherwise it will lose it upon poor water quality or serious water pollution accidents in Xin'an River basin within Anhui province. The special fund for compensation is mainly used in the industrial restructuring and optimization of industrial layout, integrated river basin management, water environmental protection and water pollution control, ecological protection, etc., in the Xin'an River basin. The

agreement on eco-compensation was signed by both provinces under endorsement of MEP.

- Tai Lake in Jiangsu Province
  Measures of Jiangsu Province for Regional Compensation of Environment Resources (trial) and *Scheme of Jiangsu Province for Regional Compensation of Environment Resources in Tai Lake Basin (trial)* were issued by Jiangsu Provincial Government, respectively, in early 2008 and early 2009, to implement regional compensation system for environment resources of major rivers in the Tai Lake basin in Jiangsu province according to the principle of "who pollutes, pays; and who destroys, compensates."
  The main idea is to determine the compensation amount of which the upstream cities at prefecture level and counties (city) under its jurisdiction receive compensation from the downstream cities at prefecture level according to the formula: "compensation capital of single factor = (sectional water quality index—sectional water quality goal) × monthly sectional water amount × compensation criterion." Jiangsu Provincial Environmental Protection Bureau and Department of Finance are responsible for accounting and consolidating the compensation amount of each quarter. The Provincial Department of Finance is responsible for collecting and allocating compensation capital, which is mainly used in water pollution control for the Tai Lake basin.
  Implementation effect: among 15 major rivers flowing into the Tai Lake Basin, 12 rivers with inferior Grade-V water quality before the pilot study was conducted sharply reduced to only one river of that grade by March 2010.
- Ziya River Basin in Hebei Province
  In 2008, *Circular on Implementing the Policy of Responsibility Assessment on Cross-Border Section Water Quality Goal for Major Rivers of Ziya River Water Body and Trying out Withholding Eco-Compensation Fund* was released by Hebei Provincial Environmental Protection Bureau. Since April 2008, this policy was implemented at five cities and 57 rivers of the Ziya River basin. Water quality of the Ziya River basin improved significantly in the first year of implementation, *Circular on Implementing Responsibility Assessment on Cross-Border Section Water Quality Goal* was issued by General Office of Hebei Province Government to specify that the eco-compensation fund policy will be fully promoted in the seven top water systems within the whole province.
  Its main idea is to determine the eco-compensation amount, according to the times of COD concentration beyond the limit at cross-border sectional water quality of each city under responsibility appraisal. If the multiples of COD concentration beyond the limit are the same, in event that the entry water quality is beyond the limit and COD concentration in the cross-border sectional water continuously increased, the compensation

amount of each city under responsibility assessment will be more than that paid when the entry water quality meets the criterion (or no entry water). The Provincial Finance Department will directly withhold the compensation amount from the annual expenditure of the city according to the total withholding amount provided by the departments of environmental protection. The eco-compensation fund must be specially used in water pollution projects of the Ziya River basin.

Implementation effect: by the end of March 2009, the total eco-compensation fund withheld from five cities within the Ziya River basin reached RMB 14.3 million, and a declining trend is presented for the overall pollution level. Compared with the previous year, the average concentration of COD reduced to 42.8 % and average concentration of ammonia nitrogen 13.7 %, which achieved the best level over many years and effectively curbed sewage discharged by the upstream to the downstream. By the end of 2009, the eco-compensation fund withheld reached a total of RMB 35.7 million. Among seven top water bodies, percentage of sections with Grade-III and superior Grade-III water quality accounts for 40.1 %, increasing 9.7 % in comparison with the same period in 2008; and percentage of sections with Grade-V and inferior Grade-V water quality reduced to 9 % in comparison with the same period in 2008.

- Shayin River Basin in Henan Province

  Interim Measures for Water Environment Eco-Compensation in Shayin River Basin was promulgated by the former Environmental Protection Bureau and Department of Finance of Henan province at the end of 2008, and *Interim Administrative Measures of Henan Province for Reward Fund of Water Environment Eco-Compensation in Shayin River Basin* was jointly issued in February 2009. This policy has achieved good effect. *Interim Measures of Henan Province for Water Environment Eco-Compensation* was issued jointly by Henan Provincial Environmental Protection Bureau and Department of Finance in January 2010, to fully implement the surface water environment eco-compensation mechanism within whole province.

  Its main idea is to adopt a "two-way" compensation mechanism combined with "penalty for exceeding the limit" and "reward for reaching the standard". Compensation criteria are determined according to the formula: (concentration values monitored at section water quality—target concentration value for assessment sectional water quality) × weekly assessment sectional water amount × Eco-compensation criterion. The monitoring indexes are COD and ammonia nitrogen. Provincial departments with relevant capabilities for environmental protection and water administration are responsible for verifying compensation criterion, and the provincial financial department together with the competent departments of environmental protection conduct compensation and rewards. The compensation fund will be used for river basin pollution control and compensating

cities which have completed the responsibility goal of water environment well under jurisdiction within the province.

Implementation effect: the compensation fund withholding within the Shayin River basin amounted to RMB 650 million in the first half of 2009, and it reduced to RMB 180 million in the second half of 2009 due to improved water environment. In 2010, the preliminary achievement was achieved after an eco-compensation system for surface water environment and has been implemented in Henan province for only 3 months. The withheld eco-compensation fund totaled RMB 37.18 million, and surface water quality in Henan province has been improved significantly.

Analysis on China's River Basin Eco-compensation Features

Regardless of economic compensation for water source conservation or cross-boundary eco-compensation and pollution indemnity in river basins, they are essentially government-led eco-compensation mechanisms, which have been developed as an environmental economy policy according to the current condition of China. In such mechanisms, the government promotes eco-compensation; the relationship between the upper and lower levels of the government spurs the quick and comprehensive implementation of eco-compensation in river basins. Support from their rich financial resources ensures stable fund source for eco-compensation. Moreover, the government can make supportive policies according to the characteristics of the regions which need eco-compensation such as specific financial policies for major rivers, market-based compensation policies for regions with relatively high levels of economic development, and compensation policies based on technical projects or policies that encourages development relocation for small-scale river basins. Such policy-based eco-compensation provides more lasting effects. Meanwhile, much improvement should be addressed in China's eco-compensation in river basin, mainly including the following aspects:

(I) **The Understanding of Eco-compensation is not yet Comprehensive**
Eco-compensation areas are often backward and they suffer from poverty, and eco-compensation often closely combines with poverty alleviation. Yet in fact, eco-compensation cannot be equated with poverty alleviation and poverty alleviation cannot be solved just by eco-compensation. In addition, the existing research programs, especially eco-compensation research programs of water source protection, only focus on the existence and development of the upstream contemporary issues to be met, and hardly emphasize compensation research for future generations.

(II) **Determination of Eco-compensation Criterion Lacks Scientific Rigor and Comprehensiveness**
First, COD is mainly considered during determination of eco-compensation factor in cross-border section water quality without focusing on some

characteristic pollutants according to the actual situations of the river basin pollution. It is rare to bring small tributaries into appraisal range or consider the small tributaries, but the compensation criterion differs from that of the mainstream. Second, the eco-compensation criterion in river basins was determined under the government leadership, and is mainly prepared through direct discussion among the relevant departments, so there is lack of a scientific calculation method as the basis. The eco-compensation figures set were not an agreed price despite the upstream and downstream governments repeatedly "bargaining". So, such compensation criterion are unconvincing to the wider range of stakeholders.

(III) **The Follow-up Mechanism in Research on the Eco-compensation Fund is Insufficient**

The existing research mainly focuses more on how to obtain an eco-compensation fund, and less on how to distribute, utilize, and manage the compensation fund within the compensation receiver milieu, as well as the usefulness of the compensation funds, namely the compensation monitoring and evaluation mechanism. Thus, it is a less favorable setting for the eco-compensation mechanism to play its deserved role.

(IV) **The Dual Compensation Means of Government and the Market Need to be Further Rationalized and Strengthened**

Eco-compensation policy has promoted the combined utilization of administrative command and control instrument and economic means. From the eco-compensation practice in river basins, its implementation in each region is dominated by the government with deferring promotion due to awareness of the governments at all levels to this policy. The market means are also gradually diversified, such as the mode of development relocation, mode of water right transaction and mode of emission trading, etc. The "synergy effect" of government-led means and market-based instruments is gradually emerging. However, the government is still the main buyer of eco-compensation at present, which has resulted in a strong administrative component during eco-compensation and certain instrument constraints. It is easy to cause transaction costs that are too high by market means, and thus unfavorable for further development and maturation of eco-compensation market mechanisms. In addition, the compensation form of the government is relatively singular, mainly with capital compensation. The legality issue of eco-compensation paid by the finance still exists. Other means such as policy compensation, in-kind compensation, technology compensation, and supporting compensation are less frequently adopted.

(V) **Trans-provincial Eco-compensation in River Basin is Difficult to Promote**

During establishment of trans-provincial eco-compensation mechanisms in river basins, the upstream provinces usually appeal with high enthusiasm, while the downstream provinces passively avoid it. Therefore, except for trans-provincial water environment compensation in the Xin'an River basin

promoted at the national level, other domestic trans-provincial eco-compensations in river basins have not started substantive work. The reason lies in undefined stakeholder's responsibilities and unclear responsibilities between the upstream and downstream for water pollution control. Water quality protection compensation criterion need to be set further. Thus, the upstream provinces often provide more compensation to the upstream region within the province, but it is difficult to negotiate eco-compensation issues between two provinces from a whole watershed without promotion at the national level. For example, there is not much progress for the compensation issue between Guangdong province at downstream Dongjiang River and the three counties under jurisdiction of Ganzhou City, namely Anyuan, Xunwu, and Dingnan at the source of the Dongjiang River. The Eco-compensation of the Xin'an River Basin has preliminary progress just due to the policy issued by the State.

5.3 Conclusion and Discussion

Based on the above analysis, while giving full consideration to the specific condition of our country, we could learn from successful foreign experiences in the practice of river basin eco-compensation. Such experience includes

Promoting public involvement: The eco-compensation mechanism is a huge project, which involves a game among interested parties during its implementation. The government alone cannot solve all problems, so public participation should be fully solicited. By learning from foreign experience, making contracts based on agreement between the buyer and seller by means of negotiation among interested parties, and clearly defining the transaction amounts and expected goals of both parties, we can not only facilitate supervision and performance evaluation of compensation, but also fill the gap between the compensating party and the compensated party with various flexible compensation methods and thus helping us reach and implement the agreement. In addition, effective social participation and social supervision mechanisms should be established to construct a relatively uniform platform for the operation and coordination of policies which ensures the efficient implementation of eco-compensation in the river basins of China.

Designing transparent eco-compensation policies in river basins: The design of eco-compensation in China is mostly guided by the dominant form of government. During the actual implementation, therefore, the ecological system service provider is usually active to have equal negotiation and communication with the ecological system service beneficiary. Due to the lack of a transparent and well supervised and evaluated process, both the compensating party and the compensated party find themselves subject to weak moral and legal bonds, which seriously affect the outcomes of the implementation of compensation measures. Therefore, we should learn from foreign experience by enabling equal negotiation and talks between the

ecological service provider and the ecological service beneficiary, so that both parties can timely manage and follow up the eco-compensation project, regularly sum up the effects of related policies, and thus ensure the sustainability of the policies.

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