FOREIGN EXPERIENCE

Ecological Compensation Mechanism in Water Conservation Area: A Case Study of Dongjiang River

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Abstract. The appropriate economic compensation from downstream to upstream watershed is important to solve China's social and economic imbalances between regions and can potentially enhance water resources protection and ecological security. The study analyzes the implementation of ecological compensation policy and related legal basis under ecological compensation mechanism theory and practice patterns, based on current natural environment and socio-economic development of national origin in Dongjiang water conservation areas. Under the principle of "Users pay", the Dongjiang River is the subject of ecological compensation and recipient. By using the "cost-benefit analysis" and "cost method of industrial development opportunity", we estimate that the total ecological compensation amounted to 513.35 million yuan. When estimated by the indicators such as water quantity, water quality and water use efficiency, we establish the "environmental and ecological protection cost sharing model" and measure the total cost of protecting downstream watershed areas, the Guangdong Province, is about 108.61 million yuan. The implementation of the Dongjiang source region that follows the principles of ecological compensation and approaches are also designed.

Key words: ecological compensation mechanism, river source region, Dongjiang River.

Introduction

People living in most major rivers of Midwest Chinese are relatively poor since counties near to these water sources are restricted and prohibited for economic development, due to the environmental protection concerns. However, this reduces the chances for people living here to enhance their income. Because of the special geographical conditions, China's ecological sources of rivers are fragile and close to ecological conservative areas. Therefore, protection of the ecological environment and enhancement of residents' income become a difficult task since they are contradicted. The sources of rivers region have borne the task of ecological environment construction and protection for a long time that restricted the development of regional resources and economic development. Because of these restrictions, a gap of socio-economic development between upstream and downstream watershed areas emerges that is seriously affecting the enthusiasm to protect the ecological environment of the upstream region, increasing the pressure for upstream areas ecological and environmental protection. For this reason, to resolve China's regional socio-economic imbalances, the issue regarding water resource protection is important for ecological security and has urgent needs. The theory of ecological compensation mechanism based on practice patterns in China's Dongjiang Water Conservation District is one of the typical rivers that have been identified for the regional ecological compensation and compensation mechanism. By exploring the subject and object of determining compensation principles, methods, the East River source region of ecological protection and ecological compensation programs and operating mechanism design, this study aims to establish and improve the ecological compensation mechanism that can be used for potential policy making.

Literature Review

Watershed between the upstream and downstream areas upon environmental governance, ecological construction and protection of water resources development results in different utilization of the existence environmental resources. With the implementation of the ecological compensation mechanism, watershed win-win situation within the administrative and sharing, and promote watershed coordinated development among regions can be achieved [2]. Protection of ecological compensation through the administrative, legal and market means brings the benefits from ecological protection environment due to various restrictions and the loss of the opportunity to develop the upstream region preferential policies, capital, technology and other forms of physical Compensation [3]. In the theory of ecological compensation, foreign studies focused on the prospects for ecological compensation, along with ways to achieve ecological compensation process including the U.S. government's soil and water conservation compensation mechanism, the German Elbe river basin ecological compensation mechanism, as well as Costa Rica Hydro funding for afforestation upstream [4].

Domestic ecological compensation research has also made some valuable results. Zhuang provides a preliminary analysis of the externalities on the protection of ecological issues [5]. Liu Yi studies the water resources management strategy for China [6], while Qin et al. work on resources compensation in Songliao Basin [7] and Zhou et al. [3] focus on the utilization of water basin resources. Xiang et al. [8] examine thecompensation in the basin water source protection for ecological functions of forests and water conservation, Tao et al. [9] focus on water conservation on forest in Miyun Reservoir to evaluate the ecological benefits. Gao examines the water pollution damage compensation for the inter-regional compensation mechanism of river pollution [10], while Ge studied competitive compensation with water in the basin on cross-regional water transfer environmental impact studies [11] along with the competitive analysis of external water study by Zhang et al. [12]. In practice local governments have established urban drinking water protection and administrative mechanism in the small watershed ecological area including Guangdong Province Dongjiang basin ecological compensation practices, Zhejiang Province water rights trading mode and Fujian province downstream watershed ecological compensation.

For the past five years, ecological compensation mechanism for East River source in Jiangxi has aroused the concern of domestic scholars. Research focused on watershed ecosystem services on the economic value of accounting functions such as sources of forest resource value of [13] while Liu et al. estimate the total economic and ecological service value in Dongjiang River Source District [14]. In addition, few scholars have discussed the establishment of ecological compensation mechanism in Dongjiang source including Hu et al. [15], Hu and Liu [16] and Hu and Xiong [17]. These studies mainly from the value of ecosystem services in Dongjiang River based on the presumed ecological compensation standards. Their results indicate that the total amounts of compensation funds are far exceeded the benefits from regional economic development and it is difficult for the application of compensation policy. In addition, no studies and official responses on legal basis, compensation project design, compensation cost can be used to establish the compensation mechanism.

Characteristics and Establishment of Ecological Compensation Mechanism of Dongjiang River

Geographical Characteristics

Dongjiang River locates Jiangxi Province that mainly flows through Xunwu, Anyuan, Dingnan. These three counties are in the territory of southern Jiangxi (Ganzhou city) and their location are between longitude 114° 47' to 115° 33', latitude 24° 29' to 25° 33'. Total land area within the watershed is estimated to 3,502 km². Dongjiang water district includes the Longchuan, Heyuan Zijin, Huiyang, Huizhou, Borowcounties in Guangdong Province and therefore, it provides about 70% of fresh water needs for Dongguan, Huizhou, Shenzhen and Hong Kong.

Socio-economic Development Characteristics

Dongjiang River is the Central Soviet Area during the agrarian revolution where economic development is backward; people's standard of living is low. The proportion of the poor people within these counties accounts for 42% of total population. For this reason, Xunwu and Anyuan are still the key national poverty alleviation counties and Dingnan is a key provincial poverty alleviation county.

In 2004, the total population within the river source accounts to 82.93 million, of which agricultural population is about 71.4 million. The GDP is 3.147 billion yuan, which is accounting for 0.9% of the province's GDP. Farmers' per capita net income is 1,664.46 yuan, only 56.37% and 36.7% of provincial and national farmers' per capita income. Farmers' per capita income within the three poor counties is about 6% if compared to the Pearl River Delta region.

Environmental Problems and Causes

Ecological problems in East River mainly come from the degradation of water conservation capacity that caused serious soil erosion and regional water pollution. According to the 2005 survey, a total area of 85,370 soil erosion hm² in East River region has been lost. Among which, 27,871 hm² or 32.64% is eroded seriously. In 2001, measured siltation is about 1,530,000 m³, accounting for 86% of reservoir capacity. According to Douyan power station, the average annual runoff of the region is 1.421 billion m³ in 2005, more than 6% of the estimated average annual runoff. According to the environmental monitoring stations in Ganzhou, water quality in some of the water body is classified as IV or low V in 2006.

Dongjiang source causes more complicated ecological problems. First one is due the inherent disadvantages of natural and geographical conditions. The area is a typical mountain for agriculture and forestry where 90% of the land is mountainous, hilly and steep mountains which is prone to soil erosion. Second ecological problem comes from the directly discharged of regional solid waste and untreated sewage into water bodies that pollute the fruit and aquaculture industry. Combined with other agricultural nonpoint pollution, the scope and extent of the contamination for agricultural and livestock products is increasing. The slag accumulation of a large number of non-treatment and sewage discharge on soil and water also cause serious pollution. Third, forest resources are severely damaged. Timber processing industry consumed a large number of forest resources, resulting in degradation of forest ecosystems and soil erosion. The erosion area increases 10 folds compared to the 1950s. The fourth ecological problem comes from the impact of large-scale mountain development. At present, fruit deforestation phenomenon tendency to expand that exacerbating soil erosion for mountains with more than 25° slope. The last ecological problem is the long-term impact of mineral development. Intensive exploitation of the minerals leads to permanent damages of local ecological environment.

Key Issues for Ecological Compensation Mechanism Several Key Issues

Recognition of Who Pays and Receives the Compensation

Ecological compensation includes the basin water conservation compensation that can be divided into national and regional downstream/upstream regions. State compensation paid to the upstream region by the central government for the watershed ecological construction is in a form of financial grants and subsidies. Construction investment in ecological environment of upstream river must pay a reasonable share of the various forms of compensation. Upstream compensation requires that local government directly engaged in ecological compensation for individuals and organizations. The current watershed protection and compensation is to compensate downstream regions by the nation.

Taking the actual compensation operation feasibility into account, Guangdong Provincial Government is the direct compensation subject while the management and the urban residents are indirect beneficiaries.

Receptors on compensation in the East River region need to sacrifice for the protection of water resources and dedication of enterprises. Units and individuals including regional governments, businesses and farmers should be compensated. In practice, the upstream businesses and individuals administrated by local governments is determined as a direct compensation object and the upstream local governments receive compensation if the upstream areas of the businesses, and farmers are determined as an indirect compensation object.

Calculation of Dongjiang River Compensation

Compensation Standard and Calculation Method

In this study, we use the cost/benefit analysis and industrial development opportunities for cost accounting to compute the impacts on Dongjiangyuan ecological construction and environmental protection. By considering the downstream region's economic development level, we can ultimately determine the compensation standards to protect water resources. Dongjiang River water resources are to be protected via human, material and financial resources. It is difficult to estimate the input costs and benefits that have already been compensated in the past. Therefore, based on Development and Reform Commission of Jiangxi, the Environmental Protection Bureau of Jiangxi and the socio-economic reality, Kong estimates that the cost of Dongjiang River environmental protection and ecological construction is about 1.42 billion yuan [19].

Costs Constitute Environmental Protection and Ecological Construction Project

In accordance with the ecological protection and construction in East River source from the "Eleventh Five-Year" project summary combined Jiangxi Statistical Yearbook 2006, the project investment arrangements and cost estimates are summarized as follows:

1. Direct investment in environmental protection: water monitoring, environ-

mental cleaning and watershed protection, soil erosion and other aspects of economic investment in Anyuan, Xunwu and Dingnan counties is about 239 million yuan. The average annual direct investment in environmental protection is 19.92 million yuan.

2. Ecological compensation for protection of forest and loss in returning farmland investment including the compensation for afforestation, forest conservation, and loss in farmland. According to the "Eleventh Five-Year" plan, the project costs 183 million yuan and the estimated average annual investment in ecological compensation for forestry and farmland protection is 15.25 million yuan.

3. The loss of the right to development. Using adjacent counties disposable per capita income of residents and compared to upstream regions disposable income, economic losses reflect the right to development restrictions. Compensation calculation formula is as follows [20]:

Annual compensation limit = (per capita disposable income of urban residents - per capita disposable income of urban residents in upstream counties) × upstream urban resident population + (per capita income of farmers − upstream farmers per capita net income) × upstream rural population.

We use the 2005 per capita income of urban residents in river regions, per capita net income for rural people, and related indicators to calculate the adequate compensation. The selected neighboring counties including Dongguan, Huizhou City, Ganzhou City, Yudu County, Long

County and Xinfeng are used to set up compensation standards. The results show that all compensated counties should receive compensation amounted to 271.06 million yuan intotal while annual compensations for Anyuan, Dingnan and Xunwu are 10.78 million yuan, 35.23 million yuan and 225.05 million yuan, respectively. Total compensation within 3 years are amounted to 288.3 million yuan [19].

Cost-sharing Simulation of Environmental Protection and Ecological Construction in Dongjiang River

Dongjiang source along with Anyuan, Xunwu and Dingnan play an important role in forestry ecological construction, soil erosion, ecological agriculture, rural non-point source pollution control and ecological migration projects, constituting a zone for watershed environmental protection and ecological construction. The total cost of environmental protection and ecological construction is ultimately reflected by the current and improved water quantity, and therefore, the amount and quality of water supply must be measured from upstream to downstream areas. This study is to consider three indicators such as water quantity, water quality and water efficiency of upstream watershed areas of environmental protection and ecological construction zone for cost-sharing and compensation. Based on Liu et al.'s study in 2006[21], we establish the cost-sharing model for Dongjiang River Basin environmental protection and ecological construction:

$$C_{gd} = C_T \times K_{sl} \times (1 + K_{sz}) \times K_{xy} .$$

The formula:

C_{gd} — the cost of environmental protection and ecological construction for Guangdong;

C_T — the total cost of watershed protection and ecological construction;

K_{sl} — Water partition coefficient in Guangdong Province (the proportion of total water basin);

K_{sz} — Water quality correction factor based on river water quality monitoring sectors;

K_{xy} — Water Efficiency partition coefficient based on the water consumption in various regions.

Cost-sharing model is used to determine the parameters including: water partition coefficient. River basin area of environmental protection, soil erosion control, ecological construction requires a lot of manpower, material and financial input to not only ensure that the entire basin of water supply and water quality, especially for downstream watershed area that offers plenty of clean water, but also ensure that the entire watershed. According to the Dongjiang river basin water resources utilization, water distribution coefficient can be calculated as the proportion of total water consumption, namely:

$$K_{sl} = SL_{Downstream} / SL_{Total} .$$

The formula:

S_{lK} — Water partition coefficient;

$SL_{Downstream}$ — Dongjiang River downstream areas;

SL_{Total} — Total water consumption.

Water Efficiency distribution coefficient. Benefit-sharing model suggests that the compensation should be high for areas with high environmental protection and ecological construction costs, and should be low for areas that bear less environmental protection and ecological construction costs. Watershed areas that are not bearing environmental protection and ecological construction costs should nt receive any compensation. Therefore, environmental protection and ecological construction in the cost-sharing model introduced water efficiency sharing factor. According to water consumption per 10,000 GDP, it is calculated as:

$$K_{xy} = (1/HS_{Downstream)} / (1/HS_{Raw} + 1/HS_{Preparation}).$$

The formula:

K_{xy} — Water Efficiency partition coefficient;

$HS_{upstream}$ — Water consumption per 10,000 GDP in upstream watershed areas;

$HS_{Downstream}$ — Water consumption per 10,000 GDP in river basin region.

Water quality correction factor. Water quality affects development and utilization of water resources in the basin and also determines the water use value. If the water quality of upstream watershed areas is better, the more value it will provide to the downstream; if the upstream region has to offer low quality water, and limited value could it bring to the downstream. Therefore, environmental protection and ecological assumptions embedded in the basin cost-sharing model introduced

downstream water quality correction factor on the watershed area. COD concentration, usually used as an indicator regarding water quality in the field of environmental protection can be monitored for downstream watershed regions in Dongjiang environmental zone. Water quality standards for areas adjacent to the downstream watershed region required to monitor the BZ (mg / L), and the River Basin District has the responsibility to ensure that the water quality reaches the normal standards for downstream water.

When the actual water quality follows the standards, the downstream watershed areas only need to share the cost of environmental protection and ecological construction and when the cross-section at the provincial border is less than the actual water standard; the downstream watershed areas share the benefits when they gain from the environmental protection and ecological construction costs. Using the annual emissions reduction units COD investment TZ (ten thousand yuan/t) estimates in upstream watershed areas, the upper basin area provides better quality than the standard compared to the SP times TZ.

When the SJ in cross-sectional is higher than the actual water quality standards (that is, BZ), the upstream water quality is not qualified. Therefore, the upstream region receives the compensation from downstream areas for the cost of environmental protection and ecological construction. However, upstream region also needs to compensate the downstream for the unqualified water supply. This compensation is calculated by the difference amount of COD discharge between standards SJ and BZ, which is the SP times TZ. Thus, water correction factor is calculated by the following formula:

$$K_{ss} = SJ / BZ .$$

K_{ss} – Water quality correction factor;

SJ – The actual COD concentration;

BZ – Water quality standards for COD concentration in environmental protection zone.

The parameters are determined by data collected where the annual runoff in East River region is about 3.2 billion m^3 and the average annual water supply in Guangdong province is of 2.921 billion m^3. Planned provincial water quality is classified as type II, the 2005 estimated annual water consumption per 10,000 yuan in upstream areas is about 650 m^3 and is about 290 m^3 in Guangdong in 2004. Ratio of investment from national ecological construction and environmental protection to local investment is about 7:3 which means Guangdong Province only affords 30% of total environmental protection cost of upstream. According to the above cost-sharing model and the determined parameters calculated, the results indicate that (1) Guangdong Dongjiang source compensation annually 1.086 billion yuan, of which every year Anyuan, Xunwu and Dingnan Counties must afford the environmental protection and ecological construction cost for 21.723, 76.029 and 10.861 million yuan , respectively.

Implementation of Ecological Compensation Principles and Pathways

Ecological compensation does not refer to the upstream and downstream watershed between the various administrative units by simply compensating each other directly; instead it refers to all administrative units within the self-compensation and co-ordination basin between the various administrative compensation units. The internal administrative unit of self-compensation is a prerequisite while the co-ordination between various administrative compensation units is the goal. However, these two kinds of compensation are complementary and indispensable. Dongjiang River ecological compensation area should be a single administrative unit within the number of administrative and co-ordinary compensation because the various internal administrative units are self-compensated.

Our basic approach is to repay old debts in the beginning. Repayment of water through compensatory measures regarding past debts on ecological destruction and environmental pollution is necessary. Second, do not owe the new account. Economic development should be based on comprehensive consideration of water environment functional compliance requirements. The third step is to accelerate economic development. In compliance with the condition of environmental industry, water carrying capacity to achieve rapid development is the premise. The fourth step is to make the development harmonious. The regional aquatic ecosystems supporting force should be focused on the coordinated regional economic and residential development.

Overall speaking, the goals are to (1) establish the water outflow quality standards and administrative unit within the jurisdiction of water quality standards and (2) make co-ordination between the various administrative compensation units. Water basin co-ordination between the various administrative compensation units by the administrative unit is the responsibility of the government to monitor the various administrative units directly with each compensation or damages.

Improvement of the Central Financial Compensation Mechanism

Compensation mechanism in Dongjiang river should be led by the Government. At the government level, ecological compensation mechanism for inter-provincial river basin should be established by the central government. The East River in Jiangxi and Guangdong provinces are typical watershed and the central fiscal policy is important to adjust the overall socio-economy. In China's current financial system, the special fund and fiscal transfer payment system for the establishment of ecological compensation mechanism plays an important role. In the East River source region, local government can try to establish the ecological compensation fund in Dongjiang basin and the central government can increase the regional fiscal transfer payments in Dongjiang River project for compensation. In the country to implement a proactive fiscal policy, the provinces that monitor the Dongjiang river need to set up arrangements for the implementation of the regional forest and natural forest protection project including the Pearl River

Shelterbelt Project, watershed management, agricultural development, poverty alleviation and development, food for work, rural biogas, national key ecological forest management and protection and a series of projects that support the project in the form of investment in the source region. Ecological construction is one type of the implementation projects, which greatly improve the ecological environment of the source region and to a large extent, it eases the ecological construction difficulties due to lack of funds. In the future, the central government still needs to support with a great effort in the Dongjiang River project.

Improvement of the Provincial Financial Compensation Mechanism

Dongjiang river projects are eligible for the ecological compensation and tax breaks. Compensation mechanism in regional level mainly refers to the Jiangxi Provincial Government that increases the transfer payments to the counties that are in ecological and environmental protection and increases the project budget and investment arrangements. Jiangxi has been paid much attention and funds to specific projects such as the renewable energy development, eco-industrial park projects, efficient utilization of resources projects, forestry and ecological construction projects, soil and water conservation projects, ecological agriculture and rural construction projects, mining and environmental protection, ecological restoration, urban environmental engineering investment on the East River region. Meanwhile, from the tax aspects, the counties close to Dongjiang River have less tax burdens,

especially for the source area with industrial restructuring process about the development of ecological agriculture, high-tech industries and resource-saving eco-industries. Business tax and land use fees implementation is a time-limited exemption policy to help industrial restructuring and the source region.

Establishment of Ecological Compensation Mechanism in Cross-Administrative Areas

Establishment the ecological compensation mechanism for administrative regions across the East River has underlying principle. It requires the long-term compliance with the law to ensure water quality, the diversification of animals to achieve mutual benefits. Specifically, we measure the erosion in sensitive areas of Dongjiang River for the implementation of the forestation project. In 2009, Xunwu County started the forestation project with the economic compensation policy that is based on national grain subsidies which can be as long as 16 years. This trial helps local government to determine the benefits and effects from ecological compensation for the loss of fruit industry in upstream. In addition, it determines the annual reasonable burdens including the cost of ecological construction and environmental protect that the downstream region are required to bear. Guangdong Province estimates that the related expense in the East River is of 1.086 billion yuan, which will be amortized for 8 years. Among the cost, Anyuan, Xunwu and other three counties that are in the south of environmental protection and ecological construction region need to afford 21.72

million yuan, 76.03 million yuan and 10.86 million yuan, respectively. The compensation for land that is currently used in the production of grains that will be used in forestation can be compensated for a period of 16 years while the compensation for upstream ecological construction and environmental costs can be compensated for a period of 8 years. Moreover, there should be some compensation for the lost opportunity of industrial development in this region. According to the results, Guangdong Province should subsidize the annual compensation for the East River region including Anyuan, Xunwu and other counties for the loss of industrial development opportunity for 271.06 million yuan, 225.05 million yuan and 35.23 million yuan, respectively. This part of the compensation can be taken according to the compensation standard

in the form of the implementation of the supported projects and the development of upstream areas. This helps the upstream regions to strengthen their ability to build a number of low pollution areas with significant economic returns while new industrial projects can help the economic development of upstream areas into a virtuous cycle and get rid of a variety of compensation programs gradually. To explore the capital, technology and management advantages in the East River region where has relatively low land rent and labor resources as well as fruit industry, vigorously development of ecological agriculture, ecological fruit industry to high-quality fruit industry group improves the ability of the these areas to establish industrial development that helps the development of upstream area into a virtuous cycle.

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