

## **GAME ANALYSIS AND SYNERGISTIC MECHANISM OF WATER RESOURCES PROTECTION STAKEHOLDERS IN JIANGHUAI ECO-ECONOMIC ZONE**

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### **ABSTRACT**

The water resource is an important guarantee for the economic and social development of the Jianghuai eco-region. Carrying out water resources protection is conducive to the better realization of the development strategy of the region. The protection of water resources involves many stakeholders, so there will be certain conflicts among different stakeholders due to different interest demands, thus affecting the effectiveness of water resource protection. Based on identifying and analyzing the stakeholders of water resources protection in the Jianghuai Eco-economic Zone, this paper conducts a game analysis among the important stakeholders, and further proposes a synergistic mechanism for water resources protection in the Jianghuai Eco-economic Zone.

**Keywords:** Water Resources Protection; Stakeholders; Game Theory; Stakeholders; Synergistic Mechanism.

### **Introduction**

"Jianghuai Eco-economic Zone", located in the lower reaches of the Yangtze River and Huaihe River, is a functional economic zone delineated in full cooperation with the National Grand Canal Cultural Belt and the National Jianghuai Ecological Corridor. The construction of Jianghuai Eco-economic Zone should adhere to the concept of harmonious coexistence between man and nature, but the environmental problems in some areas of the region are outstanding.

Water is the soul of an eco-economic zone, so we must pay more attention to the protection of water resources while promoting economic development. The protection of water resources involves the sustainable and coordinated development of the economy, society and environment; the game, contradictions and conflicts among different stakeholders in the management of water resources in the river basin affect the efficiency of governance. The protection of water resources involves the interests of multiple regions and basins, which cannot be solved by any single party independently. Therefore, it requires the coordination of various stakeholders to achieve the long-term protection of water resources in the Jianghuai Eco-economic Zone.

Most of the existing studies on the Jianghuai Eco-economic Zone advocate the development of green industries and suggest linking the protection of ecology with the development of industries, such as tourism and ecological agriculture. However, there are few studies on the pollution and protection of water resources in the Jianghuai eco-region, especially the description of the conflict between stakeholders in water resources protection is almost blank. Therefore, this paper aims to provide effective support for the construction of a synergistic mechanism for water resources protection in the Jianghuai Eco-economic Zone by addressing the conflicts between stakeholders in water resources protection, especially between the government and enterprises.

## **1. Stakeholder identification and analysis of water resources protection in the Jianghuai Eco-economic Zone**

Stakeholder was initially proposed by Stanford Research Institute in 1963. Freeman defined it as: Stakeholders are individuals or groups who influence or are influenced by the performance of organizational goals. Some scholars believe that those who influence the life and death of an organization are stakeholders. In this context, stakeholders are groups or individuals whose lives or production activities have an impact on water resources in the Jianghuai Eco-economic Zone, such as governments, enterprises, farmers and other members of the public in the region, as well as some non-governmental organizations.

In the absence of certain agreement constraints, these stakeholders will pursue the maximization of their interests, which may harm the water resources of the ecological economic zone. If these stakeholders can work together to pursue their collective interests and establish a reasonable synergy mechanism based on cooperation and contractual constraints, they can effectively contribute to the protection of water resources in the Jianghuai Eco-economic Zone.

### **1.1 Government**

The government plays a leading role among the multiple actors of ecological governance, but the public and the market are inherently weak. The government mechanism is too powerful in ecological governance, which to some extent squeezes out or even excludes the space for social

and market actors to play their roles, and further emphasizes the weakness of the latter.

The government is a double subject: it is both an economic and a public subject. The dual identity of the government makes the government assume the dual management functions of economic and public affairs management. The government's economic and public affairs management functions, give the government a unique advantage in overcoming the shortcomings of the market mechanism in water rights trading, to compensate for the limitations of the market mechanism, which is unmatched by any other organization. In addition, the government, as a power center and an institutional system composed of administrative series subordinate to layers, endows it with a dominant position in the social game in which the government and non-government entities participate, making the government's involvement in water resources management activities more effective. realistic feasibility.

## **1.2 Enterprise**

In retrospect, Anhui Province has made great efforts to promote a new type of industrialization here. Generally speaking, the industrial added value in Jianghuai Eco-economic Zone accounts for a relatively high proportion in Anhui Province at present, but some areas have become impetuous because of their strong desire for development, and then some chemical enterprises, such as the salt chemical industry, chemical plants and paper mills, have been introduced, which have polluted the rivers within the region. These low-end industries produce a large amount of chemical and industrial waste, which seriously pollutes local water resources. In addition, there is plenty of water systems in the Jianghuai Eco-economic Zone, so the water transportation industry is also relatively developed. However, the excessive development of water transportation also brings some pollution to water resources to a certain extent.

## **1.3 Farmers in the ecological zone**

The Jianghuai Eco-economic Zone is the most developed agricultural area in Anhui Province. A large area of still rural land exists around the lake cluster. The proportion of water inferior to Class V in the region is still relatively high, and the pollution of agricultural water sources is relatively serious, among which the pollution of livestock and poultry breeding is the main source of pollution. Farmers live and produce along the lake, making a large number of chemical fertilizers, pesticides and poultry discharges are discharged into the lake water, causing a serious burden to the lakes and rivers in the region.

## **1.4 Other social publics**

In terms of access to environmental information, the public is usually in a passive position. The disclosure of environmental information by government departments is not timely or sufficient,

so it is difficult for the public to obtain environmental information from government departments, and they can only passively accept the information provided by relevant government departments, which also causes the public to have insufficient understanding of environmental information; the public has little understanding of their own environmental rights and interests (the right to know the environment and the right to make decisions in environmental management). Therefore, when their own rights and interests are violated, the public cannot clearly know which of their own rights and interests have been violated, or how to effectively maintain them.

The public is the direct victim of pollution and an important subject of ecological governance. The increasing importance of quality of life and the availability of environmental information have led the public to express their concerns about environmental problems in the Jianghuai Eco-economic Zone in a conscious and organized manner in recent years, and to express their strong demands for its management.

## **2. Stakeholder game analysis of water resources protection in Jianghuai Eco-economic Zone**

The above analysis shows that in the process of water resources protection in the Jianghuai Eco-economic Zone, the government and enterprises, the two most important stakeholders, are bound to play a game in the equilibrium configuration of water resources protection in the Jianghuai Eco-economic Zone due to their different interests. During water resources protection in Jianghuai Eco-economic Zone, although relevant social organizations and the public will supervise the implementation of water resources protection, the implementation of self-interest demands makes enterprises conspire with relevant stakeholders or carry out water resources protection in Jianghuai Ecological Economic Zone as little as possible, illegally. The government mainly makes macro policies to control the protection of water resources in the Jianghuai Eco-economic Zone. Also, the mandatory promoter is bound to pay more than the amount of cost when it further micro-manages the implementation of the balanced allocation of water resources protection in the Jianghuai Eco-economic Zone. Therefore, for the government, the ability to enhance supervision of the balanced allocation of water resources in the Jianghuai Eco-economic Zone depends on the cost of supervision versus the loss of social benefits from non-supervision.

Therefore, for water resources protection in the Jianghuai Eco-economic Zone, there is a degree of the game between the main stakeholders, i.e., government and enterprises, and it is dynamic and in the context of insufficient information. Therefore, this study constructs a dynamic game model between the government and enterprises with incomplete information to provide effective support for analyzing the effectiveness and economic rationality of the government's supervision actions in water resources protection in the Jianghuai Eco-economic Zone.

## 2.1 Game order between government and enterprises in water resources protection in the Jianghuai Eco-economic Zone

For the convenience of the study, it is noted that the government is S and the enterprise is R, respectively.

According to the analysis, there are multiple signaling games between S and R, and there is an obvious "information asymmetry" between R and S, i.e. S knows exactly the level  $\theta_j$  of its supervision in water resources protection in the Jianghuai Eco-economic Zone, but R does not.

The game between the two sides generally follows the following order:

(1) "Nature" (N) acts to choose the type  $\theta \in \Theta$ ,  $\Theta = \{\theta_1, \theta_2, \dots, \theta_n\}$  of government S. S knows  $\theta$ , but R does not, it only knows the prior belief  $p(\theta_j)$  about S's level  $\theta_j$  of supervision in water resource protection in the Jianghuai Eco-economic Zone, and  $\sum_{j=1}^n p(\theta_j) = 1$ .

(2) S takes actions first according to  $\theta_j$  in order to transmit "the government's supervision strength  $d_j$ " to R. R generally believes that "the government's supervision strength  $d_j$ " reflects the government's supervision level  $\theta_j$  and  $d_j$  is positively related to  $\theta_j$ . This is because the higher the level of S's supervision, the higher the cost of its supervision and the stronger S's supervision will be. Assume that the probability distribution of S's supervision level in water resources protection in the Jianghuai Eco-economic Zone is  $\theta_j$  when it shows a supervision effort  $d_j$  B is  $\sigma_j = \{p(d_1 | \theta_j), p(d_2 | \theta_j), \dots, p(d_j | \theta_j)\}$  and is consistent with  $\sum_{j=1}^n p(d_j | \theta_j) = 1$ .

(3) After observing the supervisory effort  $d_j$  of S, R uses Bayes' rule to obtain the posterior probability  $\tilde{p} = p(\theta_j | d_j)$  from the prior probability  $p = p(\theta)$ , and then will take the corresponding action  $k \in K$ . Here K is the action space of R, and  $K = \{\text{violation, no violation}\}$ . When  $d_j$  maintains at a high level, R is likely to be punished by government fines and other penalties for violating the law; when  $d_j$  maintains at a low level, R will not only not be fined or even likely to earn a certain amount of revenue for taking violating actions.

**2.2 Basic assumptions of the game between government and enterprises in water resources protection in the Jianghuai Eco-economic Zone**

From the general order of the game between the two sides, we can construct a signal game model between S and R, and put forward the premise assumption of this model:

- (1) the game is infinitely repetitive;
- (2) both S and R are fully rational;
- (3) in the initial stage, R is not aware of the type of S and only has a priori beliefs  $p(\theta_i)$  about the type of S. Also, S is not aware of the probability  $v_j = p(k|d_j)$  of R's violation.
- (4) After the first stage, R is able to derive the posterior probability  $\tilde{p} = p(\theta_j|d_j)$  of S's type based on S's supervision strength in the previous stage, and S is aware of R's probability  $v_j$  of violation in the previous stage.
- (5) Both R and S are able to decide their actions in the next stage based on the information obtained in the previous stage.
- (6) The equilibrium functions of R and S depend on the probability  $\sigma_j$  of supervision of R by S and the probability  $v_j$  of violation of R, and the probability  $\sigma_j$  of supervision of R by S and the probability  $v_j$  of violation of R converge toward the equilibrium.

For the purpose of the following study, the following definitions are proposed:

Definition 1: The refined Bayesian equilibrium of the supervised and constrained model of S over R in terms of water conservation in the Jianghuai Eco-economic Zone is a combination of the strategic combination  $(d^*(\theta), k^*(\theta))$  and posterior probability  $\tilde{p} = p(\theta|d)$  that satisfies:

$$(1) \quad k^*(d) \in \arg \max_d \sum_{\theta} \tilde{p}(\theta|d) v_2(d, k, \theta)$$

$$(2) \quad d^*(\theta) \in \arg \max_d v_1(d, k^*(d), \theta)$$

(3)  $\tilde{p}(\theta/d)$  is obtained by R to observe the signal  $d$  and the optimal strategy  $d^*(\theta)$  of S (where possible) from the prior probability  $p(\theta)$ , by using Bayes' rule.

### 2.3 Benefit analysis of government and enterprises in water conservation in the Jianghuai Eco-economic Zone

#### (1) Benefit analysis of R

Let the gain of R be  $v_1(d, k, \theta)$ , then

$$v_1(d, k, \theta) = P \times p(k/d_j) \times p(d_j) - E(c/k) \times p(k/d_j) \times p(d_j) - F \times p(\theta_j) \times p(d_j) \quad (1)$$

Including:

$P$  - the revenue that R should have according to the income level of the enterprise after performing the water resources protection in the Jianghuai Eco-economic Zone.

$E(c/k)$  - the expected cost of R in fulfilling the water resources protection of Jianghuai Eco-economic Zone.

$p(k/d_j)$  - the probability of R's violation when the supervision of S is  $d_j$

$p(d_j)$  - the probability that S is supervised with the intensity of  $d_j$

$F$  - the amount of punishment that R will receive from the government due to the violation of water resources protection in the Jianghuai Eco-economic Zone.

#### (2) Analysis of the benefits of S

Let the benefit of S be, then  $v_2(d, k, \theta)$

$$v_2(d, k, \theta) = F \times p(\theta_j) \times p(d_j) + T + M(\theta, k, d) - H(\theta_j) - P \times p(k/d_j) \times p(d_j) \quad (2)$$

Including:

$T$  - the benefits of S due to the supervision of water resources protection in the Jianghuai Eco-economic Zone.

$H(\theta_j)$  - the supervision cost of S when the level of water resources protection supervision in the Jianghuai Eco-economic Zone is  $\theta_j$

$M(\theta, k, d)$  - other benefits of S due to water resources protection supervision in the Jianghuai Eco-economic Zone, such as social benefits and ecological benefits.

#### 2.4 The establishment of a dynamic game model between government and enterprises in water resources protection in Jianghuai Eco-economic Zone

From Definition 1, it is clear that the optimal choice of R is that

$$k^*(d) \in \arg \max_d \sum_{\theta} p(\theta / d) v_2(d, k, \theta) \tag{3}$$

Therefore, it is possible to obtain:

$$\begin{aligned} & \arg \max_d \sum_{\theta} p(\theta / d) v_2(d, k, \theta) = \\ & \arg \max_d \sum_{i=1}^n \left[ \left( \frac{p(d_i / \theta_j)}{p(d_i)} \right) P \times p(k / d_j) \times p(d_j) - E(c / k) \times p(k / d_j) \times p(d_j) - F \times p(\theta_j) \times p(d_j) \right] \\ & = \arg \max_d \sum_{i=1}^n p(d_i / \theta_j) [P \times p(k / d_j) - E(c / k) \times p(k / d_j) - F \times p(\theta_j)] \end{aligned} \tag{4}$$

It is also able to know from definition 1 that the optimal choice of S is that

$$d^*(\theta) \in \arg \max_d v_1(d, k^*(d), \theta) \tag{5}$$

Therefore it is possible to obtain:

$$\arg \max_d v_1(d, k^*(d), \theta) = \arg \max_d [F \times p(\theta_j) \times p(d_j) + T + M(\theta, k, d) - H(\theta_j) - P \times p(k / d_j) \times p(d_j)] \tag{6}$$

To solve Eq. (3-6) for the first order partial derivative of  $p(k / d_j)$  and let the partial derivative equal to 0, we can get.

$$p^*(k / d_j) = \frac{P_{\theta}}{E(c / k)} \tag{7}$$



Where:

$P_\theta$  --R reward gain at the level  $\theta$  of S supervision

To solve the first order partial derivative of  $\theta_j$  of Eq. (3-7), we can get:

$$\frac{\partial H(\theta_j)}{\partial p(\theta_j)} - \frac{\partial M(\theta_j, k, d)}{\partial p(\theta_j)} = P \times p(d_j / \theta_j) - F \times p(d_j) \quad (8)$$

Therefore, the refined Bayesian equilibrium of the model can be derived as

$$(\theta^*, p^*(k/d), \tilde{p}^*(\theta/d)) = (\theta^*, \frac{P_\theta}{E(c/k)}, \frac{p(\theta, d)}{p(d)})$$

### **2.5 Analysis of the dynamic game model between government and enterprises in the water resources protection of the Jianghuai Eco-economic Zone**

(1) When the level of water resources protection supervision in the Jianghuai Eco-economic Zone of S is low, then  $\theta$

$$\frac{\partial M(\theta_j, k, d)}{\partial p(\theta_j)} - \frac{\partial H(\theta_j)}{\partial p(\theta_j)} < P \times p(d_j / \theta_j) - F \times p(d_j) \quad (9)$$

that is, the marginal benefit of S's water resources protection supervision in the Jianghuai Eco-economic Zone is smaller than the benefit obtained by R, indicating that the optimal strategy of S is not to implement supervision at a low level of supervision.

(2) When the S has a high level  $\theta$  of supervision, then

$$\frac{\partial M(\theta_j, k, d)}{\partial p(\theta_j)} - \frac{\partial H(\theta_j)}{\partial p(\theta_j)} > P \times p(d_j / \theta_j) - F \times p(d_j) \quad (10)$$

that is, the marginal benefit of S's supervision is greater than the benefit obtained by R. Now, R will be punished for violations of water resources protection in the Jianghuai Eco-economic Zone, leading to a reduction in its benefits. At this point, R's optimal choice for water resource protection in the Jianghuai Eco-economic Zone is not to violate the law.

### **2.6 Conclusion of the game analysis between government and enterprises in the Jianghuai**

### **Eco-economic Zone**

The results of the game analysis between the government and enterprises in the evolution of water resources protection in the Jianghuai Eco-economic Zone show that the government, in order to effectively promote water resources protection in the Jianghuai Eco-economic Zone, should continuously improve its own level of supervision, and promote water resources protection in the Jianghuai Eco-economic Zone in the system through the construction of the supervisory team and the formulation of policies related to water resources protection in the Jianghuai Eco-economic Zone, thus ensuring the effectiveness of water resources protection in the Jianghuai Eco-economic Zone.

### **3. Synergistic mechanism for water resources protection in the Jianghuai Eco-economic Zone**

Currently, water environment governance in China is managed regionally, hierarchically and sectorally according to the administrative authority, with high governance costs there, insufficient incentives, and a lack of full mobilization of relevant parties' motivation and initiative. From the perspective of all-around economic and social development, for the protection of water resources, we should not only pay attention to ecological environment protection, but also coordinate regional economic development and people's livelihood needs, and comprehensively consider various interests. The theory of collaborative governance and the practice of water resources protection prove that the core of the collaborative mechanism of water resources protection lies in achieving maximum universality and sharing among the government, enterprises and society; and based on this, the leading role of the government, the dominant position of the market and the beneficial complement of social participation should be given full play to establish a collaborative mechanism of water resources protection and water ecological governance covering the whole watershed and ecological economic zone.

(1) Governmental measures such as 1) improving the legal protection system for water resources, establishing a cross-regional and cross-departmental coordination mechanism for water resources protection, promoting network construction and information sharing, improving the coordination mechanism for water pollution disputes, incorporating water resources protection and management indicators into the government assessment and evaluation system, strengthening the working system and assessment mechanism for the river and lake systems, and enhancing the government's ability and enthusiasm for water resources protection; 2) improving the inter-provincial joint meeting system at the horizontal level, i. e., taking into account the actual situation of each province, taking into full consideration the actual needs of the overall development planning and construction of the Jianghuai Ecological and Economic Zone, as well as the regional functional positioning and industrial layout of the upper, middle and lower

reaches of the basin when formulating the 14th Five-Year Plan; respecting and considering the regional differences under the premise of unified planning, and formulating corresponding supporting implementation plans.

(2) Market measures, such as 1) sounding market dominance in water resources allocation and water pollution management, improving the effectiveness and efficiency of water resources development and utilization, introducing a third party in water pollution management, and establishing a "polluter pays, third party management" mechanism; 2) establishing a water price mechanism at the basin level that is commensurate with the use of water resources and the cost of water pollution control, coming to a scientific allocation of water resources and sewage rights on the basis of existing water conservancy projects, to give full play to the fundamental role of water rights and sewage rights trading and other market-based means in water resources protection, and to establish a scientific and reasonable market-based and diversified ecological compensation mechanism for water resources; 3) making full use of market-based mechanisms to mobilize enterprises and social forces to participate in water environment management and green development of the basin, to reduce the occupation of public resources by water resources protection, and to improve the efficiency of green development of the basin.

(3) Society. The coordination of all sectors of society is an important part of the coordination mechanism of water resources protection. Social governance theory believes that social organizations are professional and rationalized. Stakeholders such as social organizations and the public play an important role in the protection of water resources in key watersheds. Effective supervision from social organizations and the public helps the government to get rid of the dilemma of regional interest coordination. Social organizations and the public can become important participants in the governance of the water environment in the basin by actively participating in environmental impact assessment, monitoring and reporting of environmental disputes and water public interest litigation related to water resources protection. Social organizations such as watershed ecological environmental protection can make up for the shortcomings of government and market mechanisms. Public opinion monitoring can not only improve the transparency of government decisions but also effectively prevent and avoid the failure of market mechanisms. Therefore, the incentive and guarantee mechanism of social participation should be improved to fully stimulate the enthusiasm of social organizations and public participation.

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