The Conditionality of Wetland Ecological Compensation: Supervision Analysis Based on Game Theory

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Abstract: Wetland ecological compensation (WEC) is the key to the conflict between wetland conservation and economic development. While “conditionality” is critical to the efficiency and equity of WEC projects, supervision guarantees the conditionality and effects of WEC policies. Based on field research around the Poyang Lake, this paper applies game theory to systematically analyze WEC supervision and leverages the model of dynamic game with incomplete information to discuss the effects of weak supervision on rural households’ future behaviors. The results show that (1) weak supervision greatly dampens the effects of WEC projects; (2) the key underlying causes of weak supervision include low compensation rates, low default costs, and low probability of actual supervision, and the respective relevance of the three causes is not parallel but decreasing; (3) further analysis based on the model of dynamic game with incomplete information demonstrated that weak supervision affects rural households’ current and future behaviors. The paper concludes that, in order to address the roots of weak WEC supervision, appropriate compensation rates should be developed; default costs should be increased; and the actual supervision probability of authorities should be raised. The paper provides detailed explanations of real-life problems and fills the gap in the existing research by defining “weak regulation”, exploring its root causes, and comprehensively analyzing and forecasting its impacts.

Keywords: wetland ecological compensation; conditionality; supervision; game theory

1. Introduction

Wetlands are unique ecosystems that not only serve as shelters for human beings, but also provide resources for human life and production. In addition, wetlands boast important ecological and environmental functions, including soil and water conservation, climate regulation, and biodiversity protection. Ranked the fourth around the globe and the first in Asia, China is endowed with vast areas of wetlands. However, the booming economy encroaches on about 340,000 ha of wetlands every year (Thirteenth Five-Year Plan for Ecological Environmental Protection (http://www.gov.cn/xinwen/2016-12/05/content_5143464.htm, accessed on 13 June 2023)), posing severe threats to the wetlands’ capacity for ecological protection, water storage, and flood control. Wetland conservation has, therefore, become a popular yet challenging topic worldwide. After joining in the Convention on Wetlands, China has adopted various policies and measures to protect and restore wetlands. The most noteworthy measure is wetland eco-compensation based on wetland nature reserves. This eco-compensation program, implemented by the Chinese government, can be seen as a replica of the state-led Payments for Ecosystem (PES) mechanism, which is a voluntary transaction between users and providers of environmental services, resulting in
conditional payments for compensated environmental services based on mutually agreed-upon regulations for natural resource management [1]. WEC, as a type of eco-compensation, is naturally an important practical innovation in the PES program. In 2009, China officially piloted wetland eco-compensation, and the country has made huge achievements over the past 13 years. In 2014, Several Opinions of the CPC Central Committee and The State Council on Comprehensively Deepening Rural Reform and Accelerating Agricultural Modernization proposed that farmland be returned to wetland, that wetland eco-compensation projects be developed, and that wetland protection awards be presented. Eco-compensation has thus become an integral part of China’s wetland protection mechanism. In 2018, China’s Ministry of Finance issued the Guidance on Establishing and Improving the Long-term Mechanism for Ecological Compensation and Protection in the Yangtze River Economic Belt, proposing the establishment of an incentive mechanism by integrating general and dedicated transfer payments. In December of 2021, The Wetland Protection Law of PRC (the Law) was issued; it came into effect on 1 June 2022. As China’s first legislation dedicated to wetland protection, the Law specifies that “a national system of WEC shall be established” and that “fiscal investments shall be expanded in wetland protection”. As an important policy tool, WEC contributes to mitigating the tension between wetland conservation and economic development.

WEC is an institutional arrangement that regulates the interests of wetland conservation stakeholders with the purpose of conserving and sustainably using wetland ecosystem functions and services, with economic instruments as the primary means [2–4]. Between China’s WEC and PES, there are differences in at least four aspects: first, voluntary participation must be guaranteed in PES projects, or, in other words, “ecosystem service providers should voluntarily participate in PES projects”. Nevertheless, voluntary participation is difficult to guarantee in eco-compensation projects such as wetland eco-compensation projects, because they are large-scale projects supported by government payments. Second, conditionality is emphasized in PES projects, and “payments are made only if the ecosystem service providers actually provide the services, adopt a specific land use pattern or follow the natural resource management agreements”. However, conditionality is often neglected in eco-compensation projects. Third, PES projects adopt the principle of “payment by beneficiaries”, whereas in wetland eco-compensation projects, the payments are made by both the beneficiaries and polluters. Fourth, PES projects are generally not related to poverty alleviation, whereas wetland eco-compensation projects are often linked with, if not used as a means of, poverty eradication.

Internationally, conditionality is essential to eco-compensation projects. Conditionality is not only a prerequisite of PES, but also the key incentive prompting ecosystem services. The conditionality of eco-compensation is defined as follows: “The ecosystem service providers can only be compensated if they obey the natural resource management agreements, or adopt a specified land use pattern [5]”. A comprehensive supervision mechanism is crucial to the conditionality of WEC, which not only incentivizes rural households to fulfill their eco-protection responsibilities, but also maximizes the effects of eco-compensation policies. However, most developing countries ignore “conditionality” in eco-compensation projects. Based on the research on eco-compensation projects in Bolivia and Vietnam, Wunder [6] concluded that supervision is ineffective, if not absent, in many projects. In these projects, eco-compensation payments are more well-meaning grants than exchanges with ecosystem services. Conditionality is related to supervision intensity. Dated supervision methods and high supervision costs are barriers to achieving conditionality in eco-compensation projects. Conditionality is also related to voluntary participation. If voluntary participation is hindered by problems such as low compensation rates, ecosystem service providers may violate the agreements on natural resource management [7]. In China, “conditionality” directly impacts the efficiency and effects of WEC projects. Conditional eco-compensation involves the attainment of related goals. For example, fishing shall be strictly banned in no-fishing zones, and wildlife such as migrant birds shall be truly protected. As supervision is the key to successful eco-compensation payments, monitoring the fulfillment of these goals requires a control mechanism and effec-
tive supervision. Therefore, thorough research into WEC supervision is vital to conditional eco-compensation, and is of practical significance to the realization of WEC policy goals.

In practice, as China has yet to establish a WEC supervision system, problems including illegal hunting, illegal grazing, weak protection, and disordered regulation [8] still pose obstacles to achieving conditionality in WEC projects. Generally, academia pays more attention to compensation rates [9–12], compensation methods [13,14], compensation mechanisms [15–17], compensation models [18,19], the willingness to accept compensations [20,21], the policy preferences [22–24], and the effects of eco-compensation policies on farmers’ willingness and to protect wetlands and their related behaviors [25], but overlooks supervision in WEC projects. This paper uses game theory to discuss the concepts, features, and causes of “weak supervision” in WEC projects. Furthermore, the model of dynamic game, with incomplete information, is used to comprehensively analyze and forecast the effects of weak supervision. Finally, tailored policy recommendations for improving supervision mechanisms are proposed.

The major contributions of the paper are as follows: (1) Previous studies have suggested that wetland eco-compensation fails to incorporate “conditionality” and demonstrates “weak supervision”, but they have not addressed the root causes and solutions. The paper, however, gives detailed explanations of the problem by defining “weak supervision” and proposing three root causes, namely, low compensation rates, low default costs, and low probability of actual supervision. (2) Previous studies have simply described the supervision issue in eco-compensation, but neglected systematic analysis. The paper, however, applies game theory to the case of the Poyang Lake wetland to provide a comprehensive analysis and forecast of the effects of weak supervision, and offer targeted policy recommendations.

The remainder of this article is organized as follows. The next section comprises the research area and data sources. This is followed by an analysis of WEC supervision based on game theory. The subsequent two sections apply a definition, as well as the features and causes, of weak supervision, and analyze them based on dynamic game theory. The last two sections include discussion, conclusions, and policy implications. The analytical framework of the research is shown in Figure 1.

![Figure 1. The framework of research.](image_url)
2. Research Area and Data Sources

2.1. Research Area

The Poyang Lake is located in Northern Jiangxi Province, at the south bank between the middle reach and the lower reach of the Yangtze River. With its drainage area extending to 162,225 km$^2$, the lake is renowned as China’s largest freshwater lake. The distinctive seasonal hydrological changes enable the lake to provide vast shelters for a variety of species. The wetland of Poyang Lake is one of the six largest wetlands in the world, and was among the first wetlands to be included in the *List of Wetlands of International Importance*. By providing wintering habitats for migrant birds and other endangered species, the wetland is a giant species gene pool that supports biodiversity. As a lake wetland, it plays the role of the “Kidney of Earth” and has significant ecological, economic, and social functions. This wetland is a real-life example demonstrating the protection of global biodiversity and the harmonious co-existence between nature and human beings. Therefore, the Poyang Lake is a very representative scientific research area. The red area in Figure 2a represents Jiangxi Province, in China. The blue area in Figure 2b represents the Poyang Lake in Jiangxi Province, and the red area in Figure 2b represents the research area.

![Figure 2a](image1.png)

![Figure 2b](image2.png)

**Figure 2.** The location of the Poyang Lake. (a) represents Jiangxi Province, in China; (b) represents the Poyang Lake in Jiangxi Province, and the red area in (b) represents the research area.

2.2. Data Sources

To make the research more representative, the research area was delineated to cover the prefectures and counties (townships) of the three core protection zones within the Poyang Lake watershed. Field research was conducted from 8 to 24 July 2019 in 27 villages from 14 counties (townships) in 5 prefectures (municipalities, districts), i.e., Duchang, Lushan, Gongqingcheng, Yongxiu, and Xinjian. Stratified random sampling was adopted for the research. Sample villages were randomly selected from counties (townships) in the 3 protection zones, and 26–36 rural households were randomly selected from each sample village for questionnaire surveys and face-to-face interviews. A total of 773 valid questionnaires were collected. Furthermore, the research team conducted interviews with local wetland protection authorities to thoroughly learn about the local policy implementation.

The sample characteristics and the distributions of the respondents are presented in Table 1. As most householders were male, and knew more about domestic assets and production, males accounted for 85.6% of all the samples. The average age was 55 years old, with the majority ranging from 45 to 55 years old (37.5%) and 30.7% of the respondents...
ranging from 56 to 65 years old. As insufficiently educated as the respondents might be (91.2% with a secondary school degree or less), they fully understood the questionnaire and their lack of education did not compromise the questionnaire’s validity. Most interviewed households consisted of 3–5 people (47.0%), and the average size of the interviewed households was 4 people.

Table 1. The basic characteristics of sample rural households.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Categories</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>662</td>
<td>85.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>111</td>
<td>14.4</td>
</tr>
<tr>
<td>Age</td>
<td>Under 45</td>
<td>126</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>45–55</td>
<td>290</td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>56–65</td>
<td>237</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>Above 65</td>
<td>120</td>
<td>15.5</td>
</tr>
<tr>
<td>Education background</td>
<td>Primary school or less</td>
<td>477</td>
<td>61.7</td>
</tr>
<tr>
<td></td>
<td>Junior high school</td>
<td>228</td>
<td>29.5</td>
</tr>
<tr>
<td></td>
<td>Senior high or technical school</td>
<td>51</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Above senior high school</td>
<td>17</td>
<td>2.2</td>
</tr>
<tr>
<td>Household size</td>
<td>1–2 people</td>
<td>263</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>3–5 people</td>
<td>363</td>
<td>47.0</td>
</tr>
<tr>
<td></td>
<td>6 people or above</td>
<td>147</td>
<td>19.0</td>
</tr>
</tbody>
</table>

3. Analysis of WEC Supervision Based on the Game Theory

Game theory stems from The Theory of Games and Economic Behavior, co-authored by the mathematician Von Neumann and the economist Morgenstern in 1947. According to game theory, the decision-making of each player is influenced by other players’ decision-making. Before making the most favorable decisions, each player will take into consideration the decisions of other players and the impact of their decisions on others [26]. Theoretically, there are three essential elements in a game, as follows: (1) Players: Players are the decision makers in games. There can be two or more players in a game, who can either be natural persons, groups, or organizations. Players will make the most favorable decisions to maximize their benefits. (2) Strategies. Strategies are all of the moves and decisions made by players with the existing information. (3) Payoff matrix. Each player will receive the corresponding payoff after making decisions. The value in the matrix can be positive, negative, or zero.

If WCE is compared to a game, then the government and rural households are two players, each with different benefit demands. This paper assumes that both players are perfectly rational. The government can choose to supervise or not, and rural households can choose to follow policies or not. Fishermen’s compliance with the fishing ban policy is used as an example in this section. Fishermen can either follow the policy and quit fishing, or defy the policy and continue fishing. It is assumed that fishermen will suffer a revenue loss (represented by I), but also gain compensation (represented by E), if they follow the fishing ban policy. When the government chooses to supervise at a cost (represented by C), the fishermen will be burdened with fines (represented by T) and compensation deductions (represented by P as a proportion of the compensation, \(0 < P < 1\)) if they are found to be incompliant. In cases where fishermen disobey the fishing ban policy, supervision by the government will raise its reputation (represented by W), whereas the absence of supervision will decrease its reputation (represented by Q). Based on the assumptions described above, a payoff matrix between the government and fishermen is compiled in Table 2.
Table 2. Government–fishermen game pay-off matrix.

<table>
<thead>
<tr>
<th>Fishermen</th>
<th>Supervised</th>
<th>Not Supervised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance</td>
<td>$-I + E, -C$</td>
<td>$-I + E, 0$</td>
</tr>
<tr>
<td>Incompliance</td>
<td>$(1 - P) E - T, -C + T + W$</td>
<td>$E, -Q$</td>
</tr>
</tbody>
</table>

According to the payoff matrix, in cases of $I > PE + T$, the dominant strategy for fishermen is to violate the policy and continue fishing. To put it another way, if the compliance costs ($I$) exceed the combined default costs (the sum of deducted compensations ($PE$) and the fines ($T$)), the optimum decision for fishermen is to violate the fishing ban policy. On the other hand, if the supervision costs ($C$) exceed the supervision benefits ($T + W + Q$), the dominant strategy for the government is to not supervise, regardless of the fishermen’s strategy. In summary, in cases of $I > PE + T$ and $C > T + W + Q$, a Nash equilibrium in pure strategies can be established where the respective optimum strategies for fishermen and the government are to be incompliant and not to supervise. Nevertheless, in the case of $I < PE + T$ and $C < T + W + Q$, a Nash equilibrium in mixed strategies will be established.

The probability of fishermen being compliant and quitting fishing is defined as $x$, and the corresponding probability of them being incompliant and continuing fishing is $1 - x$. The probability of government supervision is $y$, and the corresponding probability of no government supervision is $1 - y$. ($x \in [0, 1]$, $y \in [0, 1]$). The expected utility function for fishermen is:

$$U(x, 1 - x) = x(-I + E) + (1 - x)[y(E - PE - T) + (1 - y)E]$$  \hspace{1cm} (1)

The derivative of function (1) is:

$$\frac{\partial U}{\partial x} = -I + E - [y(E - PE - T) + (1 - y)E] = -I + y(PE + T)$$  \hspace{1cm} (2)

If $\frac{\partial U}{\partial x} = 0$, then $y = I/(PE + T)$.

When $y > I/(PE + T)$, $\frac{\partial U}{\partial x} > 0$, it indicates that when $y$ exceeds a certain value, the expected utility of the fishermen increases as the value of $x$ rises, and fishermen tend to be compliant. On the contrary, when $y < I/(PE + T)$, $\frac{\partial U}{\partial x} < 0$, the fishermen tend to be incompliant. When $y = I/(PE + T)$, $\frac{\partial U}{\partial x} = 0$ and fishermen are neutral towards being compliant.

The value $I/(PE + T)$ is assigned to $y^*$, defined as the “minimum effective supervision probability” to ensure fishermen’s compliance. $\frac{\partial y^*}{\partial T} < 0$, $y^*$ is negatively correlated with the fines posed for incompliance; $\frac{\partial y^*}{\partial PE} < 0$, $y^*$ is negatively correlated with the compensation deductions; and $\frac{\partial y^*}{\partial I} > 0$, $y^*$ is positively correlated with the revenue loss from being compliant and quitting fishing.

On the other hand, the expected utility function for the government is:

$$U(y, 1 - y) = y(x(-C) + (1 - x)(-C + T + M)) + (1 - y)(1 - x)(-Q)$$  \hspace{1cm} (3)

The derivative of function (3) is:

$$\frac{\partial U}{\partial y} = -C + (1 - x)(T + W + Q)$$  \hspace{1cm} (4)

If $\frac{\partial U}{\partial y} = 0$, then $(1 - x) = C/(T + W + Q)$.

When $1 - x > C/(T + W + Q)$, $\frac{\partial U}{\partial y} > 0$, it indicates that when $(1 - x)$ exceeds a certain value, the expected utility of the government will increase as the value of $y$ increases, and the government is more likely to supervise. On the contrary, when $1 - x < C/(T + W + Q)$, $\frac{\partial U}{\partial y} < 0$ and the government is less likely to supervise, and when $1 - x = C/(T + W + Q)$, $\frac{\partial U}{\partial y} = 0$ and the government remains neutral towards supervision.
The value \( C/(T + W + Q) \) is designated as a “minimum incompliance probability” and is represented by \((1 - x)^*\). If the actual incompliance probability \((1 - x)\) exceeds \((1 - x)^*\), the government tends to pose supervision. If \(\partial(1 - x)/\partial C > 0\), \((1 - x)^*\), the supervision costs are positively correlated; if \(\partial(1 - x)/\partial(T + W + Q)\), \((1 - x)^*\), the supervision benefits are negatively correlated.

According to the analysis based on game theory, (1) when compliance costs \(I\) exceed the combined default costs \((PE + T)\), the optimum decision for fishermen is to be incompliant and continue fishing. (2) If the supervision costs exceed the supervision benefits, the optimum decision for the government is not to supervise. (3) When the default costs exceed the loss from compliance, there is one minimum effective supervision probability, defined as \(y^* = I/(PE + T)\). In cases of \(y > y^*\), fishermen tend to follow the fishing ban policy to maximize their benefits. \(y^*\) is positively correlated with compliance costs \(I\) and negatively correlated with both compensation deductions \((PE)\) and fines \((T)\). (4) When the supervision costs are exceeded by the supervision benefits, there is a minimum incompliance probability, which is defined as \((1 - x)^* = C/(T + W + Q)\). In cases of \((1 - x) > (1 - x)^*\), the government tends to supervise. As \((1 - x)^*\) increases, more supervision costs are required and fewer supervision benefits are gained.

In order to explain the government–fishermen game, the phase of the evolutionary game is presented in Figure 3. If \(y\) exceeds \(I/(PE + T)\), \(x\) will gradually increase to a steady value of 1. That is to say, fishermen tend to quit fishing if the actual supervision probability exceeds the minimum effective supervision probability. The government will relax its supervision if more fishermen follow the policy. Therefore, \(y\) will gradually decrease as \(x\) exceeds \((C - T - W - Q)/(T + W + Q)\). However, the relaxation of supervision in turn induces more fishermen to violate the policy. Therefore, as \(y\) becomes smaller than \(I/(PE + T)\), \(x\) will gradually drop to a steady value of 0. Consequently, the government will find that more and more fishermen disobey the policy and conduct illegal fishing due to supervision relaxation. To cope with the increasing violations, the government imposes more punishments. That is, when \(x\) is smaller than \((C - T - W - Q)/(T + W + Q)\), \(y\) will gradually rise to a steady value of 1. Fishermen thus face huge default costs due to intensified supervision, and \(x\) again increases to a steady value of 1.

![Figure 3. The phase of the evolutionary game.](image)

**4. Definition, Features, and Causes of Weak Supervision**

4.1. The Definition of Weak Supervision

According to the previous section, there is a minimum effective supervision probability, represented by \(y^*\), with which the government can ensure rigorous compliance with WEC policies. If the actual supervision probability \((y)\) exceeds \(y^*\), the optimum strategy for fishermen is to be compliant. According to the analysis based on game theory, \(y^*\) is calculated as \(I/(PE + T)\), with the prerequisite of \(I < PE + T\) \((I\) stands for the compliance costs of fishermen; \(PE\) stands for compensation deductions due to fishermen’s incompliance; \(T\) stands for the fines posed due to fishermen’s incompliance). If the calculation is extended
to the scenario of $I > PE + T$, the value of $y^*$ always exceeds 1. That is to say, in cases of $I > PE + T$, $y (y \in [0, 1])$ is always outnumbered by $y^*$, and being incompliant is the optimum strategy for fishermen. This calculation is consistent with the analysis in the previous section.

The paper divides WEC supervision intensity into weak supervision and strong supervision. The former refers to the cases of $y^* > y$, where incompliance is the optimum strategy for fishermen. The latter refers to the cases of $y^* < y$, where compliance is the optimum strategy for fishermen.

4.2. The Features of Weak Supervision

Since WEC were implemented, wetland resources have been effectively restored and protected, and wetland ecosystem services have been improved. However, the goals of wetland protection have yet to be attained, and the wetland ecosystem remains fundamentally fragile. Wetlands still face threats of deterioration and shrinkage, including the failure to ban wetland reclamation and sand extraction, encroachments on breeding and migration grounds for endangered species (including migrant birds) by human activities, and illegal grazing in no-grazing grasslands. No dedicated authority is designated to supervise WEC projects, and no supervision mechanism has been established. The consequences include the disordered management of compensation funds and inefficiencies in compensation distribution. According to its definition, weak supervision can be represented by illegal fishing during the fence months; the dislodging and killing of endangered species, including migrant birds; and illegal wetland reclamation. According to the field survey, 28.8% of the respondents admitted that fishermen still reclaimed wetlands, conducted illegal grazing and fishing, and hunted migratory birds even though they participated in WEC projects.

4.3. The Causes of Weak Supervision

The fundamental causes of weak supervision ($y < y^*$) are either that the value of $y$ is too low, or that the value of $y^*$ is too high. Therefore, to profoundly investigate the roots of weak regulation, the paper provides a categorized discussion, which is presented in Table 3.

**Table 3.** The root causes and improvements of weak supervision in WCE.

<table>
<thead>
<tr>
<th>$I &gt; E$</th>
<th>$PE + T &lt; I &lt; E$</th>
<th>$I &lt; PE + T$ and $I &lt; E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>The minimum effective supervision probability ($y^*$)</td>
<td>Over 1</td>
<td>Under 1 = $I/(PE + T)$</td>
</tr>
<tr>
<td>The probability of strong supervision</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The causes of weak supervision</td>
<td>Lack of voluntary participation due to low compensation rates</td>
<td>Rural households take part voluntarily, but the default costs remain too low</td>
</tr>
<tr>
<td>Improvements of weak supervision</td>
<td>A more reasonable compensation rate</td>
<td>Increased default costs</td>
</tr>
</tbody>
</table>

(1) Scenario 1: $I > E$. Rural households will take part less voluntarily due to the low compensation rates.

In scenarios of $I > E$ (the compliance costs exceed the compensations which rural households can obtain), the opportunity costs will exceed the compensation rates if rural households participate in WEC projects. As rural households consist of rational, economic men, they will not voluntarily participate in WEC projects. If the maximum default costs are not higher than the compensations ($E > PE + T$), it can be inferred that $I > E > PE + T$,
and that $y^*$ will exceed 1. As a result, $y$ is always outnumbered by $y^*$, and incompliance will always be the optimum strategy for rural households regardless of the supervision intensity. To summarize, in cases of $I > E$, it is the lack of voluntary compliance stemming from low compensation rates that induces weak supervision.

As shown in Table 4, 543 of 773 (70.2%) interviewed rural households said that the compensation rates were too low or relatively low; 222 rural households (28.7%) found the compensation rates to be acceptable; only 8 households (1.0%) deemed the compensation rates relatively high. To conclude, most rural households subjectively felt that the opportunity costs would exceed the compensation rates if they participated in WEC projects. The findings of the field research are consistent with the theoretical analysis; whether the supervision is strong or not, rural households will not rigorously follow the policies.

### Table 4. Rural households’ opinions on the current WEC compensation rates.

<table>
<thead>
<tr>
<th>Compensation Rates</th>
<th>Frequencies</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too low</td>
<td>179</td>
<td>23.20</td>
</tr>
<tr>
<td>Relatively low</td>
<td>364</td>
<td>47.10</td>
</tr>
<tr>
<td>Acceptable</td>
<td>222</td>
<td>28.70</td>
</tr>
<tr>
<td>Relatively high</td>
<td>8</td>
<td>1.0</td>
</tr>
<tr>
<td>Very high</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(2) Scenario 2: $PE + T < I < E$. Rural households voluntarily participate in WEC projects, but default costs remain too low.

In cases of $PE + T < I < E$, as the compensation rates outnumber the opportunity costs, voluntary participation is guaranteed. However, the difference between default costs and opportunity costs indicates that the value of $y^*$ still exceeds 1. Therefore, regardless of the supervision intensity, the optimum strategy for rural households remains to be incompliant. In this scenario, the root cause behind weak supervision is low default costs.

In the field research, 480 of 773 (62.1%) interviewed rural households said the compensations were distributed on time, and 293 rural households (37.9%) held the opposite opinion. The main reason why some rural households perceived a delay in compensation distribution was that, in the eco-compensation projects on migrant bird protection, some county (township) governments would distribute the compensations in batches to guarantee the effectiveness of the project. For instance, the government would distribute 80% of the compensations at first, then grant the remaining 20% if rural households passed the evaluation. To simplify the analysis, this paper assigns the value of 20% to “$P$” (meaning that 20% of the compensations will be deducted if rural households do not comply with compensation agreements). On the other hand, 16 of 773 interviewed rural households were fined for their incompliance. As the average fines amounted to RMB 722 and the average compensation rates were RMB 3000, a value of 24.1% was assigned to “$T$” (fines for incompliance with compensation agreements).

If $P$ and $T$ are combined, the default costs account for 44.1% of the compensations. However, the proportion of 44.1% may be overestimated. Since WEC projects are sponsored by dedicated funds, it is uncertain whether the government truly deducts 20% of the compensations for incompliant behaviors. According to local government staff, the 20% deduction would sometimes be delivered to rural households in spite of their incompliance. All of this being said, 44.1% is still too low for default costs. With this proportion, even when voluntary participation is guaranteed ($I = E$), $y^*$ will be 2.27 (far beyond 1), and rural households will choose to be incompliant regardless of the supervision intensity.

(3) Scenario 3: $I < PE + T$, $I < E$, and $y < y^*$.

In cases of $I < PE + T$ and $I < E$, the default costs exceed the opportunity costs, and $y^*$ is smaller than 1. As long as the government intensifies its supervision, $y$ can be raised to exceed $y^*$. In this scenario, the cause of weak supervision is the lack of supervision intensity by the government ($y < y^*$).
There are several reasons for the lower value of $y$. $y$ can be interpreted as the product of two multipliers ($y = y_1 \times y_2$): $y_1$ is the probability of rural households being supervised, and $y_2$ is the probability of incompliant behaviors being discovered. $y_1$ is positively correlated with the supervision inputs and negatively correlated with the supervision costs. $y_2$ is difficult to quantify, but is highly related to the current supervision system. Sometimes, incompliant rural households may get away with their behaviors due to information asymmetry and their circumvention actions. As shown in Table 5, 229 of 773 rural households (29.6%) said that the supervision was rigorous; 275 (36.4%) said that the supervision intensity was acceptable; and 269 (34.8%) said that the supervision was loose. Moreover, 501 interviewed rural households (64.8%) admitted their incompliance after participating in WEC projects. This number further proves that low actual supervision probability ($y$) leads to incompliance. Since villages are acquaintance societies, internal supervision among villagers may complement government supervision. Local traditions and village conventions may be leveraged to enhance supervision. Meanwhile, an information disclosure system shall be established to provide channels for public supervision.

Table 5. Supervision intensity in policy implementation.

<table>
<thead>
<tr>
<th>Supervision Intensity</th>
<th>Frequencies</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigorous supervision</td>
<td>229</td>
<td>29.6</td>
</tr>
<tr>
<td>Acceptable</td>
<td>275</td>
<td>36.4</td>
</tr>
<tr>
<td>Loose supervision</td>
<td>269</td>
<td>34.8</td>
</tr>
</tbody>
</table>

5. Analysis Based on Dynamic Game Theory

Rural households’ behaviors in eco-compensation projects are highly related to supervision intensity. Weak supervision will impact their current and future choices. Based on the model of dynamic game with incomplete information, this section analyzes the effects of weak supervision on rural households’ future behaviors.

The implementation of fishing ban policies is used as an example in this section. In cases where the opportunity costs exceed the compensations ($I > E$), the government and fishermen can be compared to two players in a game. The government’s strategy can be either to supervise or not, and the fishermen’s strategy can be either to follow the fishing ban policies or not. The government may impose strong supervision or weak supervision, but the intensity of the supervision is unknown to fishermen due to information asymmetry. If the government implements strong supervision, fishermen tend to comply with the policies. However, their compliance will cause revenue loss, because the opportunity costs exceed the compensations ($I > E$). Therefore, the equilibrium outcome in cases of $I > E$ with strong supervision is that fishermen will not participate in the fishing ban projects from the beginning. On the other hand, if the government imposes weak supervision, fishermen tend to be incompliant. However, fishermen will participate in fishing ban projects even when $I$ exceeds $E$, because weak supervision allows them to earn both the compensations from fishing ban projects and the revenues of illegal fishing. Therefore, the equilibrium outcome in cases of weak supervision is that fishermen will participate in fishing ban projects.

Right after the policy is implemented, the fishermen are unable to correctly perceive the supervision intensity. However, they will observe government actions in order to gradually evaluate the supervision intensity. The paper uses the Bayes theorem to discuss this issue.

As government authority is intimidating to fishermen, it is assumed that fishermen believe that it is highly possible for the government to impose strong supervision at first. The prior probability of strong supervision is set to be $P_{\text{strong}}$ ($P_{\text{strong}} = 3/4$), and the prior probability of weak supervision is $P_{\text{weak}}$ ($P_{\text{weak}} = 1/4$). Once a fisherman finds that his peers are able to get away with their incompliance, he will modify his judgment of the supervision intensity:
\[ P(P_{\text{strong}}|P_2) = P_{\text{strong}} \times \frac{P_1}{P_{\text{strong}}} \times P_1 + P_{\text{weak}} \times P_2 = \frac{3}{4} \times \frac{1}{4} / \frac{3}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{3}{4} = \frac{1}{2} \] (5)

According to Formula (5), the posterior probability of strong supervision is reduced by the fisherman to 1/2. If more incompliant behaviors are found to be unpunished, the posterior probability will be further reduced to 1/4. To summarize, if a fisherman observes two cases of unpunished incompliance, his subjective perspective of the probability of strong supervision will be palpably decreased. Meanwhile, the increasing subjective probability of weak supervision will drive more fishermen to participate in fishing ban projects, even if I exceeds \( E \). Nevertheless, the aim of their voluntary participation is not to follow policies and quit fishing, but to earn both compensations from fishing ban projects and revenues through illegal fishing. As a result, weak supervision induces inequity, because both compliant and incompliant rural households receive the same compensation. The inequity in turn leads to negative incentives that discourage compliant rural households from rigorously following the policies. In the end, the effects and efficiency of WEC policies will be jeopardized.

6. Discussion

The implementation of the policy of the “10-year fishing ban” in the Yangtze River was a key move to reverse the depletion of aquatic living resources in the Yangtze River. The policy of banning fishing in the Yangtze River has been implemented for three years, and the sharp decline in the amount of aquatic biological resources in the Yangtze River has been initially contained. In Nanjing, Wuhan, and other sections of the Yangtze River, the occurrence frequency of the Yangtze finless porpoise has increased significantly, and the single gathering population of Yangtze finless porpoise has reached more than 60 in some waters. The aquatic biological resources of the Yangtze River show a gradual recovery trend. In addition, the ban on fishing in the Yangtze River involves the survival, development, and well-being of 231,000 fishermen along the river. The central and local governments, at all levels, attach great importance to the livelihood resettlement of retired fishermen. For this purpose, they have formulated a series of policy safeguards and created a working mechanism of “central coordination, provincial responsibility, and city and county implementation”. The livelihood resettlement of retired fishermen in the Yangtze River has achieved phased results. However, with the marginal decline in the dividends of the compensation policy, the livelihoods of fishermen may still face difficulties in development, and their work may even be reduced. This may lead to fishing households increasing their fishing behavior, which would increase the difficulty of supervision during the later period of the ban. Moreover, during the period of livelihood transformation, the livelihoods of fishermen mainly depend on the accumulation of original capital and transitional living subsidies from the government. When the transition period is long, the long-term capital consumption easily causes the fishermen to develop negative emotions regarding their living situations and policies, which is not conducive to the social harmony and stability of the fishing area.

The implementation of ecological compensation plays an important role in the smooth and effective implementation of the “10-year fishing ban” policy. As it is highly related to the utilization of compensation funds and the equity of eco-compensation projects, conditionality is a critical consideration. With the implementation of wetland ecological compensation projects, some scholars and government departments have found common problems in the implementation of wetland ecological compensation policies, such as poaching, illegal grazing, and low management and protection [27,28]. All of these problems indicate that wetland ecological compensation has failed to implement conditional payment. Some scholars have also pointed out that the supervision and management system of wetland ecological compensation has problems such as unfavorable supervision and lax law enforcement [29], and it is necessary to strengthen this system. However, although existing studies show that wetland ecological compensation fails to realize conditional payment, and the supervision and management system of wetland ecological compensation is
imperfect, showing characteristics of weak supervision, most studies comprise systematic
descriptions of problems, and further in-depth analysis of the root causes and coping
strategies of weak supervision is lacking. This study uses the analytical framework of
game theory to systematically bolster the supervision of wetland ecological compensation;
discuss the root causes of weak supervision in detail; make a comprehensive analysis and
prediction of the impact of weak supervision; and provide a scientific basis for effective
improvement of the supervision and management of wetland ecological compensation.

The game between the government and fishermen regarding the Yangtze River fishing
ban policy can be classified as a typical zero-sum game. The term zero-sum game refers to
the competitive process in which all parties seek to maximize their own interests in the case
of limited resources. In terms of the Yangtze River fishing ban policy, the purposes of
the government’s implementation of the ban are to protect the fishery resources of the Yangtze
River and to maintain ecological balance and sustainable development. However, this
policy could be economically damaging for fishermen, who can no longer catch fish from the
Yangtze River. In this game, the government may provide incentives to ease the economic
pressure on fishermen, such as providing compensation and training opportunities or
helping them to switch to other sources of income. Fishermen, on the other hand, may
benefit from activities such as illegal fishing. The game between the two sides often involves
negotiation and compromise, with the hope of reaching a solution that will both protect the
resources and reduce the losses of fishermen.

According to the “Government—Fishermen game pay-off matrix”, when the cost
imposed on fishermen for complying with the withdrawal regulations is greater than the
cost of continuing their default activities, for their own interests, regardless of whether
the government’s supervision is strict, fishermen will choose not to comply with the
withdrawal policies and regulations, resulting in stealing fishing. When the cost paid
by the fishermen for complying with the withdrawal regulations is less than the cost
of not complying, there is a minimum effective supervision probability of $y^*$, and the
minimum effective supervision probability of $y^*$ is positively correlated with the loss of
income caused by the fishermen withdrawing from fishing, negatively correlated with the
compensation funds deducted by the fishermen for not withdrawing from fishing, and
negatively correlated with the fines borne by the fishermen for not withdrawing from
fishing. Therefore, in the process of policy implementation, to minimize the losses suffered
by fishermen due to fishing withdrawal, reasonable compensation funds should be given
to fishermen who withdraw from fishing, certain penalties should be given to farmers
who do not comply with the compensation agreement, and the default cost of farmers’
participation in the policy should be effectively increased. These measures would facilitate
the smooth implementation of the fishing ban policy and ensure the policy’s effectiveness.

This paper focuses on the lack of conditionality in eco-compensation and analyzes
the roots and effects of weak supervision. Weak supervision does not necessarily mean
ambiguous designation of responsibility among government agencies. Finding the root
causes of weak supervision is of great significance for tackling the issue. Based on the
analysis in this paper, the causes of weak regulation of wetland ecological compensation
originate from three important aspects, which are low compensation rates, low default
costs, and insufficient probability of actual supervision. These three aspects do not have
a simple juxtaposition relationship, but a progressive relationship with priority. Low
compensation rates are more relevant than low default costs, while low default costs are
more relevant than insufficient probability of actual supervision. Among these, the weak
supervision caused by low compensation rates and low default costs is due to the design of
ecological compensation policies, while the insufficient probability of actual supervision
is a regulatory problem involved in the process of policy implementation. The setting of
compensation rates is the core difficulty of ecological compensation policy design. Scientific
and reasonable compensation rates should fully consider the livelihoods of farmers, respect
the main statuses of farmers, and act as an incentive mechanism for farmers participating
in the project. The default cost is a constraint mechanism, but at the present stage, the
design of China’s wetland ecological compensation policies often ignores the problem of default cost. In addition, most ecological compensation projects have very low or almost no default costs. The actual supervision probability can be subdivided into two parts: the probability of farmers being regulated and the probability of farmers not complying with the compensation agreement being caught. The probability of farmers being regulated is related to the capital input and cost of supervision, while the probability of farmers being caught not complying with the compensation agreement is closely related to the system of wetland ecological compensation supervision. However, if a scientific and reasonable compensation rates is set during the policy design process, and there is also a relatively appropriate default cost, the probability of farmers consciously complying with the regulations will be greatly increased, and the difficulty of supervision by the regulatory authorities will be greatly reduced. Therefore, the three causes also affect each other.

7. Conclusions and Policy Implications

7.1. Conclusions

Poyang Lake, the largest freshwater lake in China, is an important habitat for rare endemic species such as the paddlefish, finless porpoise, and Chinese sturgeon. In order to protect the biological resources of the Poyang Lake area and to promote the protection of the Yangtze River and the construction of ecological civilization in its waters, the government decided to implement a ten-year ban on fishing. The prohibition of fishing by fishermen has significant positive externalities, so China implemented an ecological compensation policy to solve its externalities. Effective supervision is an important tool to ensure the effective implementation of WEC policies. Therefore, based on field research of 773 rural households around Poyang Lake, we used game theory to illustrate the supervision issues of WEC projects. The major findings were as follows:

(1) Low compensation rates, low default costs, and insufficient probability of actual supervision (defined as $y$) are the major causes of weak supervision.

(2) The respective relevancies of the three causes to weak supervision are not parallel, but decreasing: low compensation rates are more relevant than low default costs, while low default costs are more relevant than insufficient probability of actual supervision (defined as $y$). Low compensation rates and default costs indicate that the minimum effective supervision probability ($y^*$) exceeds 1 and outnumbers the actual supervision probability ($y$). Therefore, rural households will not follow WEC policies regardless of the supervision intensity.

(3) The analysis based on the dynamic game theory led us to conclude that weak supervision has a huge impact on the current and future behaviors of rural households. In cases of weak supervision, both compliant and incompliant fishermen can obtain the same amount of compensations. The negative incentives lure compliant fishermen into defying the agreements. In the end, this leads to the efficiency and effects of WEC policies being drastically disrupted.

7.2. Policy Implications

Based on the analysis described above, this paper offers the following policy recommendations:

(1) Top-level policy design should consider the ecological value of wetlands, the opportunity cost of farmers’ participation, and the farmers’ willingness to be compensated. Reasonable compensations should be provided to guarantee voluntary participation in WEC projects.

(2) Farmers who fail to abide by the compensation agreement should be punished to increase the default costs, with the intention to guarantee equity in WEC projects and incentivize farmers to protect wetlands.

(3) A well-functioning supervision system should be established, and the responsibilities of each government agency should be clearly designated to increase the actual supervision probability.
There are still limitations to this study. First, this study used self-report measures, where farmers’ verbal responses were relatively subjective and easily reflected the directionality and orientation of performance appraisal. Future studies should design more detailed and credible methodological quantifications and use more optimal survey methods to minimize the influence of subjective factors on the results. Second, this study employed cross-sectional data and did not consider bias caused by temporal dynamics. Future tracking surveys and sentinel observation studies may be used. Finally, the survey data used in this study were obtained only from Poyang Lake, China, and future studies can be expanded to include wider areas in order to explore comprehensive WEC policies for the whole country. In terms of research content, supervision and management has always been the weakest link in wetland ecological compensation policies, and it is also the link that needs to be strengthened. However, this study did not conduct in-depth research on how to strengthen and improve the supervision and management mechanisms of wetland ecological compensation, which should also be a direction of future research.

Author Contributions: J.P.: conceptualization, questionnaire development, methodology, data curation, software, formal analyses, writing—original draft, visualization, writing—review and editing, validation. Z.C.: supervision, questionnaire development, writing—original draft, resources, project administration, funding acquisition. Y.H.: writing—original draft, funding acquisition. K.X.: data curation, writing—review and editing, validation. J.L.: data visualization, writing—review and editing. J.P. and Z.C. are co-first authors. All authors have read and agreed to the published version of the manuscript.

Funding: National Social Science Foundation Youth Program of China “Research on the Mechanism, Effect and Path of Agricultural Carbon Reduction and Exchange Value Enhancement under the Background of Double Carbon Goals” (22CJY030).

Data Availability Statement: Our questionnaire is derived from a comprehensive survey initiated by China Agricultural University. Our research team does not own full intellectual property rights. If the questionnaire is made public, our research team may face the risk of intellectual property disputes. Thus, our data are confidential.

Acknowledgments: We are very honored to be funded by Major Program of National Philosophy and Social Science Foundation of China (18ZDAG048).

Conflicts of Interest: The authors declare no conflict of interest.

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