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Blood transfusion or hematopoiesis? how to select between the subsidy mode and the long-term mode of eco-compensation

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Abstract

As a long-term mechanism for eco-compensation, the ‘Hematopoiesis-Compensation Policy’ (HCP) such as industrial transformation can effectively improve the operability and efficiency of compensation policy. However, compared with the ‘Transfusion-compensation Policy’ (TCP) such as the cash subsidy, can HCP quickly achieve the goal of eco-compensation? Does HCP require more total investment in compensation funds? This paper takes the Shennongjia National Park System Pilot Zone (SNJNP) as the research area and takes the eco-compensation policy to encourage farmers to return farmland to forest as the research object. We set three different compensation modes of TCP and HCP, and study the compensation scenarios in the next 20 years. The results show that HCP can achieve the purpose of compensation faster than TCP. Although the annual payment of HCP is relatively higher at the beginning, both the annual expenditure and the cumulative expenditure will decrease significantly. Therefore, later annual expenditure and cumulative total expenditure of HCP will be lower than TCP.

1. Introduction

As an economical means to regulate the relationship of interest among stakeholders, the formulation of eco-compensation policies and their implementation mechanisms are receiving increasing attention and application from scholars and policymakers (Li and Liu 2010, Ouyang et al 2016).

In countries and regions with relatively developed socio-economic conditions, eco-compensation is mostly defined as Payment for Ecosystem/Environment Service (PES), and most of them focus on human beings paying for the ecosystem services they use from the perspective of market transactions (Engel et al 2008, Rode et al 2015). However, in developing countries and regions, socio-economic development is relatively lagging, and the degradation of ecosystems is mainly caused by the growing population and the need of economic growth (Peng et al 2019). To effectively solve these problems, more and more scholars are inclined to the concept of eco-compensation (CCICED 2007), with economic means as the main method, sustainable use of ecosystem services as the main purpose, and the adjustment of the interesting relationship among various stakeholders as the main strategy (Samii et al 2014, Bell and Zhang 2019). It will combine compensation with poverty reduction and regional development to enhance the effectiveness and sustainability of eco-compensation (Pagiola et al 2005, Martin et al 2019).

In recent years, many scholars have conducted extensive research on the basic theories, institutions, compensation standards and implementation mechanisms of eco-compensation (Kemkes et al 2010, Wei and Xia 2012, Börner et al 2017), and have made positive progress in areas such as forests (Bernard et al 2009), grasslands (Zhen et al 2014), wetlands (Spash et al 2009), farmlands (Liu et al 2019a), watersheds (Liu et al 2018 b) and nature reserves (Yang et al 2020). They have also explored diversified eco-compensation modes and some long-term mechanisms of eco-compensation with hematopoietic function (Muradian et al 2013). These measures have good ecological and socio-economic effects, which can not only promote regional ecological construction,
but also promote sustainable economic development. However, these measures have relied too much on big nationally implemented projects, and their sustainability has been questioned (Bennett 2008, Jack et al 2008, Liu et al 2018a).

The innovation in diversification and long-term mechanism of eco-compensation is a major measure to promote the coordinated development of green ecology and green economy and achieve socio-economic sustainability (Liu et al 2018c). Most of the current eco-compensation policies are ‘Transfusion-compensation Policy’ (TCP), they generally provide cash subsidies to protectors based on the direct input of ecological protection and the loss of opportunity costs as compensation standards (Drechsler et al 2007). From the perspective of the rationality of compensation standards, with the continuous improvement of the socio-economic level, the gap between the current compensation standards and protectors’ willingness to accept compensation will become larger and larger, and their incentive will continue to decrease (Xiong and Kong 2017). More importantly, benefiting from the direct cash subsidy of TCP, the economic benefits of the protectors increased significantly during the compensation period (Liu et al 2014). However, because of their strong dependence on eco-compensation, once the subsidy is stopped, they will lose the basic source of living (Fan and Chen 2019). This will undoubtedly greatly reduce the effect of the implementation of eco-compensation policies (Gao et al 2019).

Therefore, it is urgent to give full play to the role of the market and implement a long-term mechanism of ‘Hematopoiesis-Compensation Policy’ (HCP) with functions such as industrial transformation to solve the problem of ecological construction’s impact on the livelihood of the protector’s family and reach the compensation goal. There is an important hypothesis underlying HCP such as industrial transformation, the industrial development will not have negative impacts on adjacent ecosystem services provision. However, there is currently a lack of comparative research on TCP such as cash subsidies and HCP such as industrial transformation. Compared with TCP, can HCP quickly achieve the goal of eco-compensation and shorten the time? Since HCP pays additional industry adjustment costs, does HCP require more total investment in compensation funds?

Thus, this paper takes the Shennongjia National Park System Pilot Zone (SNJNP) as the research area and takes the eco-compensation policy that encourages farmers to return farmland to forest as the research object. We set three different compensation modes of TCP and HCP, predict the dynamic compensation standards for the next 20 years, analyze the speed of farmland conversion and, the changes of government funding input under different compensation mode scenarios, to select better approaches among different compensation modes.
2. Methodology and data

2.1. Study area
This article takes the Shennongjia National Park System Pilot Zone (SNJNP) as the research area (figure 1). SNJNP is located at 109°56′–110°36′ east longitude, 31°21′–31°36′ north latitude, 63.9 km long from east to west, and 27.8 km wide from north to south, with a total area of 0.12 × 10^6 hm^2 and in which cultivated area is 6.07 × 10^2 hm^2. Including Jiuhu Town, Xiang Township, Muyu Town, Hongping Town and Songluo Township, there are 25 administrative villages with a total of 6615 households and 19602 people.

Shennongjia area is located at the eastern end of the Qinba Mountains. It is the world’s representative kingdom of biodiversity. It preserves the most intact evergreen leafy mixed forest in the northern hemisphere and the complete vertical spectrum of vegetation in the northern subtropical mountains. It also has a rare peat moss wetland ecosystem in the sub-mountain, with ancient and rare unique species such as Sichuan golden monkeys. As the special geographical location, abundant natural resources, and important ecological functions, in 2017, the Overall Plan for Establishing a National Park System issued by the Chinese government officially listed Shennongjia as one of the ten national park system pilots.

However, there are currently more than 15000 agricultural population in SNJNP. In order to increase yield and pursue economic benefits, the widespread use of chemicals and high-intensity agricultural production ha brought some ecological problems such as environmental pollution, soil erosion, and reduced biodiversity. In order to protect the environment and build a national park, the Shennongjia National Park Master Plan classified 93.3% of the land area as strictly protected areas and ecological conservation areas. In order to achieve this goal, the Plan put forward that in the next 20 years, 43.21% of farmers should be immigrated, while 81.23% of the cultivated land needs to be returned to the forest and the remaining 18.77% of cultivated land should be realized green production mode.

Generally Speaking, the land after returning farmland can be planted with economic forests or farmers could do some economic activities under the forests. Thereby it will bring economic benefits to community residents. However, in the national park, the land after returning farmland can only be planted with public welfare forests to provide ecological functions for regional ecological security.

Therefore, how to formulate an effective eco-compensation policy to return farmland to forest and implement the eco-immigrants within the national park is very important for coordinating development between the ecological protection of the region and the development of farmers’ lives.

2.2. Methodology
In theory, farmers’ willingness to pay can be used as a standard for eco-compensation (Hadker et al 1997). Considering that the willingness of farmers to pay increases with the improvement of the level of economic development in the region, we set ‘Cash Subsidy for Conversion Area’ (Cash Subsidy) mode as one of TCPs, and discuss the dynamic compensation standard and the investment of eco-compensation to maintain a certain proportion of returning farmland to forest.

Second, with the development of the national economy, agricultural labor will be transferred to cities and towns. Because many current eco-compensation policies do not take into account the transfer of labor over time, some farmers who have migrated to cities are still accepting the state compensation. Therefore, we set ‘Cash Subsidy for Labor Transfer’ (Labor Transfer) mode as another one of TCPs, and discuss the speed of farmland returning and the change of compensation funds input in the context of labor transfer.

Third, because TCP cannot continuously solve the livelihood and employment problems of farmers, most farmers rely mainly on government subsidies to solve family livelihoods. We set ‘Industrial Transformation of Long-term Mechanism’ (Industrial Transformation) mode as one of the HCPs, discuss the speed of farmland returning and the input of eco-compensation funds under the background of additional government investment to industrial structure adjustment.

Under the three scenarios, the forest planted after returning farmland has a variety of ecosystem services, including supply services, regulation services, support services, and cultural services. However, in national parks, especially in strictly protected areas and ecological conservation areas, economic activities are prohibited. But the regulation services, support services and cultural services of these forests will become public goods.

2.2.1. Farmers’ willingness to return farmland to forests
According to the basic principles of the willingness survey method, the willingness of farmers to accept compensation for returning farmland to forest can be estimated based on the effective samples obtained from the survey.

Firstly, under the assumption that the government requires farmers to return farmland for the ecological protection of SNJNP, the questionnaire will collect the farmers’ willingness to return farmland to forest. Secondly, effective samples are summed and their weighted average is obtained, which is the average level of the farmers’ minimum willingness for
returning farmland to forest. The formula is as follows:

\[ E_{WTA} = \sum X_i P_i \]  

\[ E_{WTA} \] is the average willingness of farmers to receive compensation for returning farmland to forest; \( X_i \) is the willingness of a single sample; \( P_i \) is the relative frequency of this single sample.

2.2.2. Scenario I: cash subsidy mode

The Cash Subsidy mode sets up in this paper is mainly based on direct cash compensation to farmers according to the conversion area. At the same time, we predict the farmers’ willingness to accept in the next 20 years to establish the dynamic compensation standards.

Generally speaking, the willingness of farmers is affected by many factors, including household income, the ratio of agricultural income, agricultural experience, gender, age, and education level (Liu et al. 2014). However, from the perspective of annual changes, farmers’ willingness will gradually increase with the development of local socio-economic development (CCICED 2007, Pang et al. 2020), and GDP can represent the development of social economy.

Farmers’ willingness to pay \( w \) shows an increasing trend with per capita GDP \( G \), which can be described quantitatively as:

\[ w = a + b \ln G \]  

\( a \) and \( b \) are two constants to be determined.

Regarding the recent local socio-economic development level and the development plan, the growth rate of local GDP per capita in the next 20 years is set to four stages of 9%, 7%, 6%, and 5%. Starting with GDP per capita in 2019, it is possible to predict linearly the change in GDP per capita in 2020–2039.

Combined with the formula (2), the farmers’ willingness to return farmland to forest (eco-compensation standard) can be calculated in the next 20 years.

Finally, if the area of returning farmland \( s \) to be compensated is known, we can calculate the total eco-compensation funds \( Q_i \) that the government needs to pay in Cash Subsidy mode:

\[ Q_i = w \times s \]  

2.2.3. Scenario II: labor transfer mode

The Labor Transfer mode sets up in this paper mainly considers the compensation to farmers who return farmland to forest in the context of labor transfer. This scenario uses the same dynamic compensation standards as the scenario I, and limits the scope of direct cash compensation to farmers who use land income as the main source of family livelihood.

Prediction of labor structure can be used by the Age-shifting Algorithm (Wen and Yin 2006). First, assuming that the fertility rate of women of childbearing age of all ages will remain the same, so the number of newborns (0 years) per year is:

\[ P_0 = \sum_{i=15}^{49} b_i \times q_i \]  

\( P_0 \) is the number of newborns, \( b_i \) and \( q_i \) are the fertility rate and the number of women of childbearing age in the age \( i \) group.

Second, assuming that the death rate of the population in each age group is unchanged, the population \( P_{i,t} \) of 0 years old and above is calculated based on the death rate:

\[ P_{i,t} = r_{t-1,t-1} \times P_{i-1,t-1} \]  

This shows that for a certain year \( t \) the number of people with age \( i \) equal to the number of people in the lower age group of the previous year multiplied by the population retention rate \( r_{t-1,t-1} \).

Third, according to the age characteristics of the labor force, the prediction of labor force change is divided into two age groups. For the labor force in the age group 24 years and under, the structure of the labor force is assumed to be unchanged because of the stable structure of employment. For the labor force over the age of 24, the following methods are used to predict:

\[ PA_{i,t} = PA_{i-1,t-1} \]  

\[ PB_{i,t} = PB_{i-1,t-1} + PC_{i-1,t-1} \]  

\( PA, PB, \) and \( PC \) represent the proportion of agriculture, non-agricultural labor force and students respectively, that is, the proportion of agricultural labor force \( PA_{i,t} \) is the proportion of agricultural labor in the lower age group of the previous year \( PA_{i-1,t-1} \). Since most students attending tertiary institutions rarely engage in agricultural production after graduation, the ratio of the non-agricultural labor force \( PB_{i,t-1,i-1} \) and the student \( PC_{i-1,t-1,i-1} \) in the lower age group of the previous year was taken as the ratio of non-farm labor in that year \( PB_{i,t} \). By dividing the number of labors in the age groups of farmers in the next 20 years, according to the distribution of employment by age group in that year, the number of labor forces engaged in various types of employment in each age group over the next 20 years can be obtained.

Finally, comparing the agricultural labor force in each year with the total labor force in 2019, the coefficient of agricultural labor force in the next 20 years \( \lambda \) can be calculated, and the total eco-compensation funds \( Q_{II} \) in the Labor Transfer mode can be calculated, combined with the area \( s \) that needs compensation and the willingness of farmers to return farmland to forest.

\[ Q_{II} = w \times s \times \lambda \]
2.2.4. Scenario III: industrial transformation

Compared with the Cash Subsidy and Labor Transfer modes, adjusting the industrial structure is a long-term mechanism for eco-compensation that is currently being actively explored. However, there is an important precondition, the industrial development will not have negative impacts on adjacent ecosystem services provision.

The Industrial Transformation mode sets up in this article mainly considers the compensation of returning farmland based on the adjustment of industrial structure, and adopts the same dynamic compensation standard as scenario I. Based on the successful experience of other regions, there are two ways for the industrial transformation of farmers in the national park (Liu et al 2019b): one is to build an industrial development park outside the national park, hire farmers who have already returned farmland to forest, and carry out various production activities; The other approach is to develop green agriculture in traditional utilization area of the national park, or promote farmers to participate in national park interpretation, tourism management or franchise activities in the research, education and recreation area of the national park. These activities will do no harm to ecosystem services provision (He et al 2018, Chapman et al 2020).

The results of institutional surveys conducted by the author show that on average, each labor force invests 5000 to 10,000 yuan in agricultural-related industries such as agro-forestry, aquaculture, agricultural product selling and management and agro-forestry and fishery products processing industry, and the labor force can be shifted from traditional agricultural cultivation to agriculture-related or non-agricultural industries in 3–5 years.

Assume that the proportion of labor transfer in a given age group $i$ to the agricultural labor force in this age group is $r_i$. For the age group below 24-year-old, the proportion of agricultural labor force and non-agricultural labor force after the industry adjustment can be calculated respectively as follows:

$$PA_{i,t} = (1 - r_i) \times PA_{i,t-1} \quad (9)$$

$$PB_{i,t} = r_i \times PA_{i,t-1} \quad (10)$$

$PA_{i,t}$ and $PB_{i,t}$ are respectively the proportion of agricultural and non-agricultural labor force after industry adjustment in the current year, and the $PA_{i,t-1}$ and $PB_{i,t-1}$ are the proportion of agricultural and non-agricultural labor force of the same age group in the previous year, respectively.

For the age group over 24 years of age, the proportion of agricultural and non-agricultural labor force after industry adjustment can be calculated separately in the following formula:

$$PA'_{i,t} = (1 - r_i) \times PA_{(j-1,t-1)} \quad (11)$$

$$PB'_{i,t} = r_i \times PA_{(j-1,t-1)} + PB_{(j-1,t-1)} + PC_{(j-1,t-1)} \quad (12)$$

$PA_{(j-1,t-1)}, PB_{(j-1,t-1)}$ and $PC_{(j-1,t-1)}$ are the lower age group of agriculture, non-agricultural labor force and student ratio in the previous year.

At this time, the funds required for ecological compensation include industrial adjustment cost $C$ and compensation funds $Q$. Industrial adjustment cost refers to the cost required to transfer labor to non-agricultural industries or engage in non-agricultural operations. Here, the average cost obtained from agency research is used to calculate:

$$C = \sum_{i=1}^{15} k_i \times t_i \quad (13)$$

$k_i$ is the number of age $i$ labor transfers and $t_i$ is the average cost of industrial adjustment. Therefore, the total eco-compensation funds required under the Industrial Transformation mode ($Q_{III}$) is:

$$Q_{III} = w \times s \times \lambda + C \quad (14)$$

2.3. Data source

To understand the social and environmental change effects of ecological compensation in SNJNP, this paper collected basic data such as population, cultivated land and socio-economic development, and collected the data of farmers and institutions closely related to eco-compensation through the questionnaire survey.

2.3.1. Questionnaire design

According to the basis of calculation of eco-compensation standards, the questionnaire was designed with the idea of encouraging farmers to return farmland to forests. The questionnaire includes two aspects. Firstly, the basic socio-economic characteristics of the interviewed farmers, including the interviewees’ gender, age, education level, agricultural experience, and basic information such as family income, income sources, and so on. These data can be used to analyze the impact of the interviewed farmers’ socio-economic characteristics on their willingness to return farmland to forest. Secondly, the amount of compensation for the interviewed farmers’ willingness to return farmland to forest, including whether the interviewees are willing to return farmland to forest and their willingness to accept.

2.3.2. Sample surveys and interviews

The author’s team conducted a survey and questionnaire in SNJNP from July to August 2018. The survey objects were farmers who had cultivated the land and engaged in agricultural production activities.
survey covered 25 administrative villages in five townships in the national park. Each village randomly selected ten households for the survey. A total of 250 households were surveyed, with 231 valid questionnaires and an effective rate of 92.40%.

In July-August 2019, the author’s team conducted a questionnaire survey of 36 government officials and researchers from five townships, such as the Hubei Provincial Forestry Department, the Shennongjia National Park Administration, the Shennongjia National Park Research Institute, and other institutions, and obtained information on some of the industrial modes and operating parameters that could be selected when the ecological compensation measures were implemented.

2.3.3. Survey results and sample characteristics
Male farmers account for 61.54% of the sample. Farmers interviewed are mainly middle-aged and elderly laborers, 41–70 years old, accounting for 83.06% of the sample, and only 13.66% under 40 years old. 90.66% of the farmers have primary or junior high school education. 76.84% of the interviewed farmers’ family annual income is less than 16,000 yuan; the proportion of households whose working income accounts for more than 50% of household income is 58.06%, and the proportion of households whose agricultural income accounts for more than 50% of household income is 51.23%. Only 1.67% of the interviewed farmers’ agricultural experience is less than 10 years, and 87.22% of the farmers’ agricultural experience is more than 20 years. 49.17% of the interviewed farmers are engaged in part-time business, of which 70.53% work outside.

In order to analyze the changing characteristics of the employment structure of rural labor force with increasing age, this paper divides the surveyed rural labor force (16–65) into five age groups, and each group is further divided into three categories, called agriculture, non-agriculture and others (students, etc.). It can be found that in the age group of 16–20 years old, the student group accounts for the largest proportion; in the age group of 21–35 years old, the labor force engaged in non-agricultural work has the largest proportion; after 36 years old, the proportion of agricultural labor is increasing; after 40 years old, most of the labor force is engaged in agriculture (figure 2).

3. Results and analysis

3.1. Analysis of farmers’ willingness and its influencing factors
Theoretically, the willingness of farmers to return farmland to compensation can be used as the standard for eco-compensation. Based on field farmers’ survey data obtained in SNJNP and formula (1), the willingness of farmers in the region was analyzed.

The results show that, when the willingness of farmers to return farmland to forest is $3 \times 10^3$ yuan (hm$^{-1}$·a)$^{-1}$, only 3.54% of farmers are willing to retire; when the willingness is $15 \times 10^3$ yuan (hm$^{-1}$·a)$^{-1}$, the proportion of farmers willing to retire is the highest, 25.50% (figure 3). And when the eco-compensation standard for farmers to return farmland to forest in the national park is $16.97 \times 10^3$ yuan (hm$^{-1}$·a)$^{-1}$, it can satisfy 96.62% of farmers’ willingness.

Through correlation analysis, we can get the factors that affect the level of farmers’ willingness, including the household income, the proportion of agricultural income, agricultural experience, gender, age and education level (table 1). The level of compensation is negatively related to the household income and education level of the interviewed farmers, indicating that the higher the family income and the higher the education level, the lower the amount of compensation farmers is willing to accept. The level of compensation is positively correlated with the proportion of agricultural income in household income, indicating that the greater the proportion
of agricultural income, the higher the compensation that farmers want to receive. The level of compensation is also positively related to the agricultural experience and age, which show that the longer the farmer is engaged in agricultural production, the older the farmer wants to receive more compensation.

3.2. Dynamic eco-compensation standards
Using SPSS software to perform regression analysis on per capita GDP and willingness to accept for the past 70 years in SNJNP, the model parameters of formula (2) were obtained, $a = -2569.09, b = 400.07$. The degree of model fitting is high (Sig = 0.000). Based on this, the farmers’ willingness to accept in the next 20 years can be predicted and a dynamic eco-compensation standard that gradually increases with the development of the national economy will be established (figure 4).

The results show that with the development of the national economy in the next 20 years, the dynamic compensation standard will gradually increase from $2.23 \times 10^4$ yuan (hm$^2 \cdot$ a)$^{-1}$ to $3.65 \times 10^4$ yuan (hm$^2 \cdot$ a)$^{-1}$.

3.3. Scenario analyses of cash subsidy mode
If the government continues to pay cash subsidies to farmers who have returned farmland according to the dynamic eco-compensation standard established in this paper, it will encourage and maintain 96.62% of farmers to return farmland, but the cash subsidies have to be paid every year (figure 5). Once the cash subsidy from the eco-compensation policy is canceled, the effect of the implementation of the eco-compensation policy cannot be guaranteed.

According to the formula (3), the total eco-compensation funds required in Cash Subsidy mode in the next 20 years can be calculated (figure 5). The results show that if according to the dynamic compensation standard established in the previous paragraph, the total compensation funds will increase from $2.72 \times 10^6$ yuan a$^{-1}$ in 2020 to $4.46 \times 10^6$ yuan a$^{-1}$ in 2039. The cumulative total expenditure of eco-compensation funds in 20 years will amount to $73.40 \times 10^6$ yuan.

3.4. Scenario analysis of labor transfer mode
According to the formulas (6) and (7), the proportion of farmers who need to use cash subsidies to encourage to return farmland will be reduced from 96.62% to 48.96% per year, with the use of increasing dynamic compensation standards over the next 20 years (figure 6). The results show that this mode can quickly achieve the goal of eco-compensation, and fewer and fewer farmers need to return farmland.

Under the combined effect of changes in farmers’ willingness to accept and the dynamic transfer of labor force, according to formula (8), the total eco-compensation funds will increase from $2.63 \times 10^6$ yuan a$^{-1}$ in 2020 to a peak value of $3.08 \times 10^6$ yuan a$^{-1}$ and then decrease year by year, with a minimum of $2.18 \times 10^6$ yuan a$^{-1}$ (figure 6). Cumulative total expenditure of eco-compensation funds in 20 years will amount to $54.99 \times 10^6$ yuan.

3.5. Scenario analysis of industrial transformation mode
As a kind of long-term mechanism of eco-compensation, the adjustment of industrial structure will effectively promote the transfer of labor force and the growth of economy. According to the formulas (9) to (12), it is calculated that in the next 20 years, the proportion of farmers who need to use cash subsidies to encourage to return farmland will be reduced from 96.62% to 20.15% (figure 7). The results show that this mode can quickly achieve the goal of eco-compensation. After 20 years, only 1/5 farmers will need subsidies to encourage them to return farmland.

According to the formulas (13) and (14), it can be calculated that the cost of industrial adjustment and
Table 1. Factors influencing farmers’ willingness to accept.

| Household income | Ratio of agri-income | Agricultural experience | Gender | Age | Educational level |
|------------------|----------------------|-------------------------|--------|-----|------------------|
| Value            | −0.0054              | 306.15                  | 8.59   | −4.29| 6.80             | −71.11 |
| Significance     | 0.0901               | 0.0455                  | 0.0233 | <0.0001| <0.0001         | 0.0002 |

Figure 4. Dynamic compensation standards of returning farmland to forest in SNJNP.

Figure 5. Total compensation costs and compensation progress of cash subsidy mode.

Figure 6. Total compensation costs and compensation progress of labor transfer mode.
the total eco-compensation funds can be calculated (figure 7). The results show that, in the Industrial Transformation mode, although the initial stage of production restructuring needs to invest more funds to transfer labor, this part of capital is decreasing year by year, from $0.90 \times 10^6$ yuan a$^{-1}$ in 2020 to $0.98 \times 10^5$ yuan a$^{-1}$ in 2039. A total investment of $8.82 \times 10^6$ yuan is required for over 20 years.

The total eco-compensation funds are also decreasing year by year, from $3.53 \times 10^6$ yuan a$^{-1}$ in 2020 to $0.91 \times 10^6$ yuan a$^{-1}$ in 2039. Cumulative total expenditure of eco-compensation funds in 20 years will amount to $39.36 \times 10^6$ yuan.

3.6. Comparison of three compensation modes

Comparing the three different compensation modes, we can answer the questions put forward in the introduction of this paper: Compared with TCP (Cash Subsidy and Labor Transfer modes), can HCP (Industrial Transformation mode) quickly achieve the goal of eco-compensation and shorten the time? Since HCP pays additional industry adjustment costs, does HCP require more total eco-compensation funds?

The results show that the proportion of farmers who still need to compensate for returning farmland and the total eco-compensation funds in the next 20 years is different (figure 8), although the eco-compensation standard in each mode is the same and increases gradually with economic development.

As far as the progress of the eco-compensation policy is concerned, HCP which based on industrial adjustment is the fastest. In the fifth year (2024) after the implementation of the compensation policy, nearly 1/3 of the agricultural labor force has been transferred to other agricultural or non-agricultural industries, and 67.16% of farmers need subsidies to be encouraged to return farmland; in the tenth year (2029), only 35.27% of farmers need subsidies; in 2039, only 1/5 of farmers need subsidies.

In terms of the funds required by the eco-compensation policy, the Industrial Transformation mode requires the government to pay an additional industrial adjustment fee in the initial stage, which leads to a higher annual total expenditure. However, from the fifth year (2024), the annual capital expenditure ($2.86 \times 10^6$ yuan a$^{-1}$) will be lower than Cash Subsidy and Labor Transfer modes.
(3.19 × 10^6 yuan a⁻¹ and 2.96 × 10^6 yuan a⁻¹, respectively).

In the term of the cumulative total expenditure of eco-compensation funds, from the 7th year (2026), the Industrial Transformation mode (21.20 × 10^6 yuan) will be lower than the Cash Subsidy mode (21.45 × 10^6 yuan); from the 9th year (2028), the Industrial Transformation mode (25.28 × 10^6 yuan) will be lower than the Labor Transfer mode (26.22 × 10^6 yuan).

4. Discussion

In the practice of eco-compensation, due to regional differences in factors such as the structure and function of the ecosystem, and the level of socio-economic development, a variety of compensation methods have been formed. For different regions, the ecological effects of these methods may be completely different. Some of them may completely restore the ecosystem, and some may only curb further degradation of the ecosystem, but cannot fundamentally achieve the goals for the restoration of the ecosystem.

Compared with the direct subsidy mode of TCP, the HCP has obvious positive significance for promoting labor transfer, shortening the time required for ending eco-compensation policy, and reducing the investment in eco-compensation. However, there is an important hypothesis underlying HCP, the industrial development will not have negative impacts on adjacent ecosystem services provision. As mentioned earlier in the paper, the objectives of eco-compensation schemes are becoming multifaceted, including ecosystem services protection and poverty alleviation. It is very likely the development of industrials will affect the health of local ecosystems, which will undermine the eco-compensation's objectives. Therefore, the Industrial Transformation mode should be treated cautiously, especially if the main objective of eco-compensation scheme is to preserve the local ecosystems, such as some natural parks, any industrial development will be forbidden in the strictly protected areas and ecological conservation areas. At the same time, due to the lack of funds, technology and production management of farmers, as well as their awareness and experience in dealing with market risks, participants will face certain market risks. Besides, the speed of labor transfer will be affected by the socio-economic environment. The future research, as well as the design and implementation of specific eco-compensation policies, needs to consider the impact of these factors comprehensively.

Besides, the eco-compensation of national parks should be based on the actual situation of the region and the functional area division in the park, and provide eco-compensation standards suitable for the positioning of different functional areas. The time value of eco-compensation projects should be taken into consideration simultaneously. The scientificity and rationality of eco-compensation policy directly affect the feasibility of compensation policy. To determine the eco-compensation policy of a region, we need to give full consideration to the regional characteristics and the actual development plan of the region, combine theory with practice, perfect the relevant theory, and better guide the development of eco-compensation practice.

In the meantime, according to the objectives and progress of returning farmland to forest in SNJNP put forward by the Shennongjia National Park Master Plan, the time frame for the scenario was set for 20 years in this article. However, this is a long and unusual duration for an eco-compensation scheme. Considering practical factors, such as change of leadership, previous policies may be changed. Therefore, referring to the experience of eco-compensation in other regions of China, the compensation policy can be stabilized through legislation. This can avoid the risk of policy changes.

5. Conclusion

To explore and compare the advantages and disadvantages of the TCP and HCP, this paper takes SNJNP as an example, and sets up three different compensation modes. We first predict the dynamic eco-compensation standards which will gradually increase with the development of the national economy in the next 20 years, according to the willingness of the farmers to accept. Secondly, the detailed simulation and comparative analysis of the progress of returning farmland and the change process of total eco-compensation funds under the three modes in the next 20 years are conducted.

The results show that, if the government adopted HCP such as the Industrial Transformation mode, the more eco-compensation capital is required due to industrial adjustment cost in the early period. However, since the Industrial Transformation mode has a huge driving effect on labor transfer and economic growth, the government's eco-compensation expenditure can decrease significantly after some time, even lower than TCP such as the Cash Subsidy and Labor Transfer modes.

The innovation in long-term mechanism of eco-compensation is a major measure to promote the coordinated development of ecology conservation and economy growth (Liu et al 2018c). Recently, many scholars have also explored diversified eco-compensation modes and some long-term mechanisms of eco-compensation with hematopoietic function (Muradian et al 2013). Consistent with the research results of this article, HCP modes have good ecological and socio-economic effects, which can not only promote regional ecological construction, but also promote sustainable economic development (Bennett 2008, Jack et al 2008, Fan and Chen 2019).
Moreover, HCP could cultivate agricultural-related or non-agricultural industries with self-hematopoiisis, which will greatly improve the living standards of local farmers. It also enables eco-compensation to achieve its goals earlier, and significantly reduces the cumulative total investment of eco-compensation funds.

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Data availability statements

Any data that support the findings of this study are included within the article.

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