Multiple perspectives on eco-compensation of ecological migrants in the Three Rivers Headwaters Region, China

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Abstract. The purpose of the study is to determine the reasonable compensation standards for ecological immigrants in the Three Rivers Headwaters region, four calculation methods were proposed according to different conditions. Results show that the minimum compensation standard for herdsmen was recommended from the current 10,000 yuan/year to 25,000 yuan/year. The highest compensation standard is proposed to, with the consideration of the quality and area of grassland, be increased by 2.5-5.0 times compared to the current compensation standard. It is expected that the current study may provide a novel perspective and reference for the compensation standards for ecological immigrants for nature reserves.

1. Introduction

Located in the hinterland of the Qinghai-Tibet Plateau, the Three Rivers Headwaters Region is the birthplace of the three major rivers of the Yangtze, Yellow and Lancang Rivers. It has the reputation of "Chinese Water Tower", and it is an important ecological barrier for social and economic development in China and even Asia [1]. During the implementation of the ecological protection projects, the relocated herdsmen paid huge costs and sacrificed development opportunities to protect the ecological environment [2]. Research on the ecological compensation mechanism of the Three Rivers Source Area is an important support for smoothly promoting the ecological protection and construction of the Three Rivers Source Area, ensuring and improving people's livelihood, which is important for the coordinated development of the western region, ethnic areas, and ecological civilization construction pioneer areas [3].

The research of ecological compensation for nature reserves is rich. Domestic scholars carried out relevant research on a series of issues including compensation standards, compensation policies, compensation objects, compensation scope and compensation methods [4-7], and at the same time,
increasing scholars pay attention to the follow-up industries of ecological migration development, ecological immigration culture and social adaptation, and attention to social security of ecological immigration, which provide important support for ecological protection in natural reserves [8-10]. At present, there are still some unsolved issues, such as the difficulty of moving immigrants and the instability of emigration [11-17]. Some studies have also calculated the ecological compensation standards for resettlement losses caused by relocation, such as the opportunity cost loss, fixed asset loss, cost of living loss, and social capital loss of the resettles, which can be reflected in the compensation standards [18-20].

Since the ecological compensation is still in its infancy, the ecological compensation mechanism is still not clear, and it is far from forming and establishing a legal system, guarantee policy and evaluation system to meet different types of ecological compensation [21]. It is necessary to formulate different compensation standards for different audiences and different goals, and gradually find suitable ecological compensation standards that can be applied to practice. This research combined with ecological footprint theory, opportunity cost, willingness survey and other methods, the current study tries to develop reasonable compensation standards for ecological migration in the Three Rivers Source Region of Qinghai Province. We hope it may provide relevant experience for the study of ecological compensation mechanisms in ethnic areas and the exploration of national parks system construction.

2. Research site description
The Three Rivers Headwaters Region is located in the hinterland and main body of the Qinghai-Tibet Plateau (N31°31'-36°15', E89°21'-102°17'). The altitude is mostly between 3335m ~ 6564m. There are 17 counties (cities) in the five Tibetan Autonomous Prefectures of Yushu, Guoluo, Huangnan, Hainan, and Haixi with a land area of approximately 295,000 km². The total population of the area is 690,000 and the pastoral population is 420,000 accounting for 60.8% of the total population. The ethnic composition is mainly Tibetan, accounting for about 90% of total population, and the others are Han, Hui, Salar, Mongolian and other ethnic groups. The economy of the Three Rivers Headwaters Region is dominated by grassland animal husbandry, and the per capita income of the district herdmen in 2018 was 6,565 yuan.

3. Research methods and data sources
The ecological footprint method, opportunity cost method, willingness to accept and willingness to pay were used to calculate the compensation standards under different scenarios. Research data was collected during the three years from 2016 to 2019, involving more than 10 towns and villages in Chengduo, Nangqian and Zaduo County of the Three Rivers Headwaters Region. A sample survey was conducted on Tibetan herders' families, and a structured interview was used to conduct a questionnaire survey. After collecting and sorting out the questionnaire, the reliability of the questionnaire was tested. Research data comes from historical data, investigation data and questionnaire. The main survey points of the typical immigration case area were Yushu and Guoluo. Heyuan New Village (235 households, 731 persons, overall relocation) in Dawu Town of Guoluo and Jiaji Niang immigrant Community (453 households, 1,555 persons, overall relocation) were selected as two topic research sites. The results of the two sampling surveys were set as variable A and variable B, respectively, and SPSS software was used to determine the correlation between the two groups of variables. The consistency of the questionnaire was tested with SPSS software, and the overall reliability is 0.86.

4. Results

4.1 An ecological footprint based eco-compensation standard
Using the ecological footprint method, the dietary consumption of 1-75 years old herdsmen in the Three Rivers Headwaters Region were calculated. Based on the average global pasture production data
(consumption/global average production) and the average market price, the Tibetan residents aged 0-75 in the Three Rivers Headwaters Region were obtained. Ecological footprint curve of consumption during the life cycle was presented in Figure 1.

Regression curve yielded a quadratic equation of one variable: \( y = -0.001x^2 + 0.37x + 0.151 \) \((r=0.94, P<0.01)\). The definite integral of the quadratic equation is 256.01\( \text{hm}^2 \). Since the grassland ecosystem services can be updated every year, the grassland area required to maintain a Tibetan herdsman (taking 75 years old as an example) for life-long dietary consumption is approximately \( \frac{256.01}{75} = 3.41\text{hm}^2 \), without degrading the quality of the grassland ecosystem.

The Three Rivers Headwaters Region is dominated by alpine meadows and alpine grasslands. Considering that the herdsmen mainly utilize animal husbandry products for grassland services, the actual carrying capacity of the region is about 1.11 sheep units/\( \text{hm}^2 \) per year [23]. The local standard of Stock Calculation was from the monitoring results of pasture production in grasslands [24]. On the premise of maintaining the grassland ecosystem without degradation, the average theoretical stocking capacity of the region is 0.43 sheep units/\( \text{hm}^2 \) per year. According to the market price (2020), it is about 500\( \text{¥/hm}^2 \). The ecological compensation standard calculation model for pastoralists is provided in formula (1):

\[
C_i = 500 \times n \times \sum_{i}^{n} F_i
\]

where \( C_i \) is the compensation standard based on the grassland diet ecological footprint (\( \text{¥/RMB} \)); the value 500 is the grassland compensation amount per unit area (\( \text{¥/hm}^2 \cdot \text{a} \)); \( i \) is the age of the herdsmen; \( n \) is the years of compensation; \( F_i \) is the grassland ecological footprint of a herdsman of age \( i \) (\( \text{hm}^2 \)). According to this method, a 50 years old immigrant could be compensated for about 13,430 RMB/a.

4.2 An opportunity cost method based eco-compensation standard

According to the monitoring and investigation of the Three Rivers Headwaters Region grassland ecosystems, the opportunity cost of the herdsmen's relocation loss is mainly livestock products such as beef and mutton, wool, cow and milk and lamb. Similarly, based on 0.43 sheep units/\( \text{hm}^2 \) per year as the standard, the value of each animal product per hectare of grassland in the area is calculated to be about 500 yuan/year. The ecological compensation standard for the herdsmen with more pastures is calculated as formula (2):
where $C_i^2$ is the compensation amount based on the loss of opportunity cost of animal husbandry; $A_i$ is the pasture area of herd $i$ (hm$^2$); $n$ is the compensation period. A household with 100 hm$^2$ could receive a total of 50000 Yuan RMB/a as their ecological compensation.

4.3 A WTA based eco-compensation standard

Although there are different bidding intervals for the unit price of compensation, households with large family pasture area are more inclined to compensate according to the grassland area, while households with small family pasture area are more willing to compensate according to the years of relocation. According to the distribution frequency of the willingness to pay for the survey, the formula (3) is used to calculate the average expected value of the willingness to pay of the herdsmen in the Three Rivers Headwaters Region ($C^3$).

$$C^3 = \sum_{i=1}^{9} A_i P_i$$

(3)

where $A_i$ is the bidding quota, and $P_i$ is the distribution frequency of the number of bidders. The proportion of bids in each interval of 100 yuan/hm$^2$·year-1000 yuan/hm$^2$·year (in increments of 100 yuan/hm$^2$·year) was 2.32%, 6.52%, 11.47%, 15.78%, 21.42%, 18.31%, 11.62%, 9.45% and 3.11%, the distribution of bidding ratio is generally olive-shaped, that is, the proportion of the two ends is small, the middle ratio is large, and the bidding rate is 600 yuan/hm$^2$·a. According to the survey data, the average willingness to pay of the herdsmen in the Three Rivers Headwaters Region was calculated to be 607.2 yuan/hm$^2$·a.

4.4 A WTP based eco-compensation standard

Based on the results of the pre-survey, the research team set a willingness to pay between 5 yuan/month and 50 yuan/month, and set the bid amount in increments of 5 yuan. In order to avoid the deviation of the bidding quantity as much as possible, the research team detailed the importance of the Three Rivers Headwaters Region and the role of ecological migration and the current status of relevant policies in the form of pictures, so that tourists can fully understand the objects of payment and their way of life. The results show that after fully understanding the relevant information on ecological compensation, up to 62.4% of the interviewed tourists chose to pay. According to the distribution frequency of the willingness to pay for the survey, the formula (4) is used to calculate the average expected willingness for the tourists to move the herdsmen in the Three Rivers Headwaters Region ($C^4$).

$$C^4 = \sum_{i=1}^{10} A_i P_i$$

(4)

Where $A_i$ is the bidding quota and $P_i$ is the distribution frequency of the number of bidders. The proportion of each bid amount of 5 yuan/month to 50 yuan/month is 28.63%, 18.36%, 15.46%, 9.58%, 7.28%, 8.57%, 5.68%, 4.23% and 2.21%. The overall distribution of bidding proportions presents an inverted triangle structure, with the highest bidding rate at 5 yuan/month. Based on the results of the above survey data, the average willingness to pay for tourists from the Three Rivers Headwaters Region is calculated to be 16.8 yuan/month. According to Yushu and Guoluo in this case, the number of tourists in 2018 was about 1.426 million. According to the 62.4% ratio, 889,824 tourists are willing to pay. According to the average per capita payment of 16.8 yuan/month, the total willingness to pay can reach 179 million yuan/year. If an effective fund management model is adopted, the per capita compensation standard can be up to 0.49 million yuan based on the number of 36,000 herdsmen who have been relocated from the two places. In 2015, based on the average family population of 5 people, the family subsidy standard can be up to 24,500 yuan/year, which can greatly alleviate the living pressure of migrants.
5. Conclusions
There are many factors involved in ecological compensation standards, which are the key and difficult points in ecological compensation research. Due to the large differences in regional socioeconomic, it is often difficult to obtain uniform and generally accepted compensation standards. This is the need to set scientific, reasonable and targeted compensation standards for different regions. Aiming at the problems of low ecological compensation standard and insufficient pertinence in the Three Rivers Headwaters Region, this paper proposed four calculating methods for ecological compensation standards, including ecological footprint method, opportunity cost method, willingness to accept method and willingness to pay method. The compensation standard obtained is about 2.5-7.6 times higher than the current annual compensation standard. The ecological compensation standard based on the ecological footprint method is applicable to the lowest compensation amount, while the compensation standard based on the opportunity cost method is applicable to the highest compensation amount, and the other two compensation standards can be used as substitutes in different situations.

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