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Realizing Benefit Sharing through Reasonable Land Compensation in the Sustainable Development of Water Resources: Two Case Studies in China

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Abstract: The existence of benefit distribution unfairness may lead to problems such as resettlement conflicts, which have become the bottleneck of sustainable development of water resources in many countries. Exploring and establishing equitable benefit sharing systems are the resolving approach, but there is still the lack of quantitative analysis tools for benefit distribution. From the perspective of benefit sharing, this study designs specific quantitative methods to determine land compensation prices that migrants deserve and makes a case analysis of two projects in China. Results suggest the following: (1) Fair compensation calculated by the input dividend method is the product of the proportion of agricultural land investment and the net income of the project, while the value summation method takes the sum of the agricultural land value, social security value and average value-added distribution as the compensation price. (2) The cases demonstrate the feasibility of the proposed methods. (3) Current policy compensation is lower than the calculated compensation, and there are insufficient migrants participating in benefit sharing in China. By referring to the estimated value of the two methods, governments or development enterprises can reasonably improve the compensation standard or provide additional follow-up support to increase the welfare of migrants, which is expected to achieve a relatively balanced allocation of benefits and realize a win-win situation.

Keywords: resettlement of migrants; water conservancy and hydropower project; benefit sharing; equitable compensation; calculation method; sustainable development

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1. Introduction

Water conservancy and hydropower construction provides important support for achieving sustainable development of economic society, carbon peaking, and carbon neutrality goals. The degree of hydropower development in Switzerland, France, and Italy exceeds 80%. Due to the inevitable expropriation or inundation of large areas of agricultural land and houses, reservoir construction has brought much population migration. As many as 80 million people may have been displaced by dams in the previous century [1]. Involuntary resettlement caused by project construction has become a worldwide problem [1,2]. At present, China has built more than 98,000 reservoirs and hydropower stations, of which the Three Gorges Project and the South to North Water Diversion Project play critical strategic roles in China's modernization drive. China is already the country with the largest scale of water conservancy and hydropower projects in the world, as well as the highest number of reservoir migrants—25 million people [3]. It is estimated that by 2026, China will need to resettle more than 200,000 migrants every year [4].

For reservoir migrants, the most severe loss of inundation is that of land, so land compensation has always been the core and key of resettlement. In countries with developed market economies, land expropriation was generally compensated according to the market price, which often took the interests of landowners into full consideration.

Moreover, methods of compensation were diversified and also attached more importance to the participation of interest groups in benefit sharing. Examples include the allocation of royalties in Brazil, the share dividend in Canada, the tax redistribution in Norway, the pre-compensation plus land leasing rent in Japan, etc. [5]. China's land expropriation compensation policy for reservoir migrants has experienced a historical process of exploration, formation, development, and continuous improvement [6]. In 2006, China promulgated the Regulations on Land Expropriation Compensation and Resettlement for Large and Medium-Sized Water Conservancy and Hydropower Projects, with appropriate amendments made in 2017. Meanwhile, in 2006, China also implemented the later-stage supporting policy for reservoir migrants, which provided direct financial subsidies and project support for rural migrants. In these policies, the land was compensated for by annual output value multiples or an integrated land section price while the later support had the function of relief, which deviated from the market value of land and the economic expectation of migrants [7]. This may have led to unsustainable livelihoods for poor and vulnerable groups, which was in great contrast to the remarkable economic and social benefits of water conservancy and hydropower projects [8]. By 2014, the impoverished population of reservoir migrants in China accounted for 20% of the total number of rural migrants, which was 1.5 times the poverty rate of the national rural population [4]. Many poor migrants suffered secondary poverty caused by changes in their living environment, reduced land resources, inadequate compensation, etc. [9]. A more serious result was that it led to mass incidents such as return migration and conflict, which became the main factor restricting the sustainable development of water conservation and hydropower [10,11]. The same happened in many other developing countries [12], and few developing countries incorporated sharing benefits of the projects into their national migration policy system. China's national counterpart support for the resettlement of the Three Gorges Project reservoir area had also achieved remarkable results. However, owing to its particularity, it was difficult to reproduce and popularize. In 2019, in order to enable migrants to better share in the benefits of hydropower projects, China issued its Guiding Opinions on Benefit Sharing in Hydropower Development, which was the first policy guideline on hydropower benefit sharing, but unfortunately it lacked operational details [5].

Deficiencies of compensation policies for involuntary resettlement in developing countries have promoted the study of benefit sharing, and many international organizations and scholars have called for the establishment of compensation mechanisms for benefit sharing [13–15]. The World Bank believes the expropriation should be conceived and implemented as a sustainable development program that must be adequately funded to enable migrants to share project benefits [16]. The World Commission on Dams has included public acceptance, recognition of rights and benefit sharing as strategic priorities for hydropower development [17]. Diana et al. believe that the motivation for benefit sharing stems from concerns about social justice, human rights, participation and empowerment, which should be incorporated into migrants' compensation [18]. Ilkhom et al. reviewed the benefit-sharing method in international resource management and proposed that the main advantage of benefit sharing was that it could transform the zero-sum game into a positive-sum game [19]. Through empirical analysis, Brooke found that the establishment of the long-term benefit-sharing mechanism between the hydropower project area and the impacted area could play a positive role in the income of migrant families [20]. Chen et al. argued that governments and owners have their own financial sources and foundation for migrants to share in the operating benefits of power stations since migrants are the losers in all spheres of economy, culture and psychology [21].

In terms of the ways migrants can share in the benefits of the project, Dai proposes sharing the costs and benefits fairly according to the principle of "who is responsible for who pays, who invests who benefits" [22]. Louis et al. categorized migrant benefit-sharing modes into four types, namely, compensation for resettlement, community development funds, corporate social responsibility, and payments for ecosystem services [23]. Zhang et al. believe that the mechanisms for migrants to share benefits of the project include

hydropower tax and fee sharing, a migrant development fund, migrant shareholding in hydropower development, long-term compensation for migrants, and preferential electricity prices for migrants [24]. Long-term compensation is an innovative approach to resettlement [25]. Wang pointed out that it was to change the static one-time compensation to dynamic long-term yearly compensation [26]. Hu argued that the implementation of long-term compensation could reduce financial pressure in the early stage of reservoir construction and also better ensure the right of existence and development of migrants [27].

In practice, by analyzing the dilemma of project benefit sharing in specific cases, Prachvuthy et al. concluded that there may still be a significant gap between the actual implementation of benefit sharing and the written commitment [28]. Duan et al. pointed out that the benefit-sharing mechanism includes issues such as an unsound system of property rights, inaccurate identity positioning, and ambiguous sharing scope [29]. There are still barriers to the application of reservoir land into shares or rental placement in terms of differentiation between operational projects and public benefit projects, quantification of sharing assessment, management, and legal assurance [30–32].

Concerning the proposal of improving the benefit sharing of migrants, Mokorosi et al. believe that there are four key factors to protect the rights and interests of affected residents in the development of water resources: appropriate legal and policy frameworks, public participation, sustainable compensation measures, and fair access to derivative benefits [33]. Fan recommended the permanent resettlement way of yearly payment, share dividends, and social security [34]. Based on the input-output analysis, Xia et al. pointed out that the benefits of reservoir migrants are significantly lower than those of other core stakeholders and suggested that the benefits of all parties should be promoted to a more reasonable and fair level by raising compensation standard for resettlement and fine-tuning power generation price [35]. Wu et al. proposed a sound benefit-sharing management mechanism for hydropower projects and giving priority to helping poor migrants escape from poverty, so as to improve the benefit-sharing mechanism for migrants in a steady and orderly way [36]. Jane et al. highlighted the roles of international financial institutions and civil society organizations in deepening the benefit sharing of hydropower development [37].

To sum up, the previous research has mainly focused on the theoretical support for benefit sharing, the qualitative exploration of sharing approaches, and the optimized path based on implementation barriers. It has been agreed that the distribution of benefits among stakeholders is unfair in the development of water resources, and that relocation may lead to migrant poverty [34,35,38]. Solutions can be provided to restore the squeezed benefit space of reservoir migrants by improving compensation prices and by other means [10,35]. However, there is still the lack of quantitative analysis of benefit distribution, and especially for the key price factor of migrant compensation, the specific algorithm and quantitative value are not given, which reduces the operability of benefit sharing in the projects.

Based on existing research, this paper further studies the following issues. First, according to the characteristics of water conservancy and hydropower projects, dynamic quantification methods for land compensation prices are proposed from the perspective of benefit sharing. Second, calculation methods are used to determine the compensation results of typical cases, which are compared and analyzed with actual compensation standards. Finally, based on the comparison results, relevant policy improvement suggestions are put forward. This paper contributes to the exploration of more scientific and reasonable benefits distribution systems in water conservancy and hydropower development, which has positive significance for enhancing the welfare of migrants and realizing social fairness and justice.

This paper is organized as follows. In Section 2, the calculation methods and the study areas and data are presented. In Section 3, two cases are used to demonstrate the feasibility and effectiveness of the proposed methods, and the measures for adjusting the benefit distribution are given. The discussion can be found in Section 4, and the conclusions are summarized in Section 5.

2. Materials and Methods

2.1. Research Methods

2.1.1. Land Input Dividend Method

The main stakeholders of hydropower projects include governments, development enterprises, reservoir migrants, etc. Their inputs are water resources, capital, land resources, etc., which together produce "hydro-energy resources". Development enterprises have obtained considerable financial gains, and governments have also received part of the benefit, such as statutory taxes. At present, migrants in China have achieved reasonable compensation for their houses. Migrants rely on land as a primary productive resource to sustain their livelihoods. Therefore, the land lost by migrants must be adequately compensated for with at least the same amount and quality of land; alternatively, new employment opportunities can be provided. Otherwise, migrants may be at risk of falling into poverty. As the core stakeholders, migrants should have corresponding rights to claim project benefits. Unfortunately, migrants often have to passively accept lower compensation based on loss of original function, which belongs to non-market-oriented compensation.

From the perspective of resource value transfer theory, the utility value of land resources forming reservoirs for projects is much higher than the planting utility value for migrants, so the use value of the expropriated land resources has appreciated [34]. The equitable compensation that migrants deserve is the utility of land resources to reservoirs, not just their own agricultural utility. The benefits of the projects include the added value of land resources after expropriation, and the sharing of these benefits should be appropriately considered for migrants [39]. Rural migrants becoming shareholders through certain procedures is an effective means to achieve their sharing benefits in project development. Theoretically, stockholder resettlement generally means that all or part of the land compensation expected to be obtained by migrants according to the policies is invested into the project as capital, and the dividends are distributed continuously according to the proportion of the shares they occupy [29,39,40]. Then, according to the amount of land expropriated, the corresponding compensation price under stockholder resettlement can be calculated, which reflects income distribution depending on input contribution.

In principle, the content received by migrants participating in benefit sharing should be the comprehensive benefits generated by the development project. The comprehensive benefits of the different projects are diversified. The benefits of operating projects such as hydropower stations may significantly outweigh the benefits of agricultural land, and land appreciation is evident and easy to calculate. However, the economic benefits of some public and quasi-public welfare reservoirs are few or none, while the social, ecological and other non-financial benefits are relatively high, although these are difficult to quantify.

In this method, it is assumed that the total investment of the project is z, land compensation expense for migrants directly used as the capital of the project is l, the construction period of the project is m, the operation period of the project is n, and the net income of the first year of operation is r. With the development of the social economy, the project revenue will increase, which is also in line with the migrants' expectation of increasing dividends. The annual growth rate of net income is expected to be g, the annual amortization expense for intangible assets formed by land input projects is f, the expropriated land area is s, and the discount rate is i, and the land compensation price is calculated as follows:

$$P = \frac{\left\{ \left(\frac{l}{z} \right) \times r \times \frac{\left[1 - \frac{(1+g)^n}{(1+i)^n} \right]}{(i-g)} + f \times \frac{\left[1 - \frac{1}{(1+i)^n} \right]}{i} \right\}}{(1+i)^m \times s} \quad (1)$$

2.1.2. Land Value Summation Method

In addition to being the means of agricultural production, agricultural land undertakes the functions of employment, pension, and medical security. It also provides the public with external benefits such as food and ecological security. From the perspective of equitable distribution of interests, land-expropriated migrants should own the agricultural use value, social security value, and partial appreciation of agricultural land conversion. In other words, migrants should not only be compensated for the existing value of agricultural land, but also be compensated for the future value. Development enterprises or governments should own other parts of the value-added income of agricultural land. The agricultural land's external benefits are eligible for incentive subsidies when used for farming, but they vanish when used for construction. As a result, they are not covered by compensation for land expropriation.

The agricultural value of agricultural land refers to the value of agricultural products produced by agricultural land and the economic benefits obtained through market transactions. Generally, reservoir migrants mostly live in remote mountainous areas and depend highly on land. When migrants are unemployed, they can at least get basic food on their agricultural land, which to some extent, has become the last line of defense to maintain basic livelihood. The social security value of agricultural land mainly covers the security value of employment, pension, and medical care. The added value of expropriated agricultural land should be reasonably distributed among the stakeholders, including migrants, development enterprises and governments. Theoretically, all land has the same rights to development and construction, but in practice, its uses and added value vary due to planning considerations. A piece of land is not an isolated appreciation but the result of a combination of many factors [41]. Therefore, it is not necessary to subdivide the current land types and planning purposes to measure the added value of agricultural land. It is advisable to measure the added value of agricultural land with the average value-added income of a certain area.

In the land value summation method, assuming that the agricultural value of land is $P_{agriculture}$, the potential social security value of land is $P_{social\ security}$, and the average value-added part of land for migrants is $P_{value\text{-}added}$, then the land compensation price is:

$$P = P_{agriculture} + P_{social\ security} + P_{value-added} \quad (2)$$

2.2. Research Area

The Yangtze River in China is the third longest river in the world. The Yangtze River Basin is relatively rich in water resources. Jinsha River is the upper reaches of the Yangtze River, and Han River is its largest tributary. In this paper, the Xiluodu Hydropower Station and the Danjiangkou Reservoir of the South to North Water Diversion Project in China were chosen as case studies to test the applicability and rationality of the quantitative method. The geographical locations of two projects are shown in Figure 1.

The Xiluodu Hydropower Station, located on the Jinsha River at the border of Sichuan and Yunnan, is the backbone project of China's western development strategy. It is the fourth-largest hydropower station in the world. The nine counties in the reservoir area are inhabited by Han, Yi, Hui, Miao, and other ethnic groups, all of which were poor counties before relocation. An overview of the project is shown in Table 1.

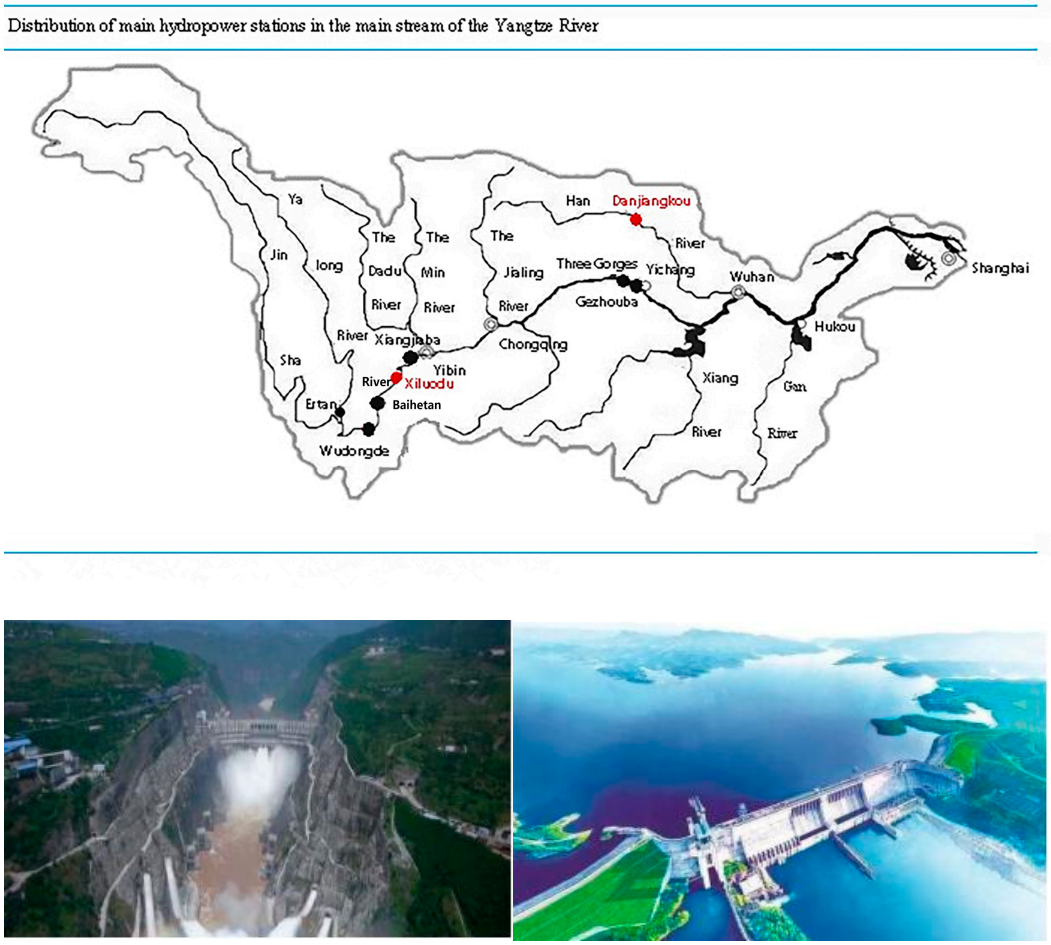

Figure 1. The location of Xiluodu Hydropower Station (**left**) and Danjiangkou Reservoir (**right**).

Table 1. Basic information of Xiluodu Hydropower Station.

Items	Contents
Period of construction	2005–2015
Installed capacity	13.86 million kW
Period of migrant relocation	2004–2013
Number of migrants	52,690 people
Total static investment	50.342 billion CNY
The costs of migrant land expropriation	2.998 billion CNY
The costs of cultivated land expropriation	1.082 billion CNY
The costs of garden plot expropriation	899 million CNY
Area of flooded cultivated land	3295.28 hm^2
Area of flooded garden plot	1355.55 hm^2
Comprehensive benefits	Power generation, flood control, sand control, shipping, environment, etc.

The South to North Water Diversion Project is an important strategic project to optimize the allocation of resources and alleviate the severe water shortage in northern China. The Danjiangkou Reservoir located in the upper reaches of Han River was formed after the Danjiangkou Dam was built and impounded in 1973. Danjiangkou Reservoir is the water source and water intake area for the South to North Water Diversion Project. In order

to better satisfy the need for water transfer, the dam-heightening project of Danjiangkou Reservoir was started in 2005. The project overview is given in Table 2.

Table 2. Basic Information of Danjiangkou Reservoir of South to North Water Diversion Project.

Items	Contents
Period of construction	2005–2014
Amount of water transferred	9.5 billion m^3
Period of migrant relocation	2009–2012
Number of migrants	345,000 people
Total project investment	230.31 billion CNY
Investment in land expropriation migration	45.787 billion CNY
Compensation cost of cultivated land	5.154 billion CNY
Compensation cost of garden plot	1.243 billion CNY
Area of flooded cultivated land	14,800 hm^2
Area of flooded garden plot	2300 hm^2
Comprehensive benefits	Flood control, water supply, power generation, shipping, ecology, tourism, etc.

Danjiangkou Reservoir of the South to North Water Diversion Project is of an operational nature and is also of public benefit [42].

2.3. Data Sources

Most of the research data of Xiluodu Hydropower Station come from the existing literature [10,34,43], while those of Danjiangkou Reservoir are obtained from questionnaire surveys, etc. Six years after the end of resettlement, the research group selected rural migrants in Danjiangkou City, Hubei Province, and Xichuan County, Henan Province to conduct a field survey by random sampling. A total of 300 questionnaires were issued, of which 273 valid questionnaires were returned. The survey primarily included basic information on the migrants, their land expropriation, production and living conditions, and willingness to pay, etc.

Basic situations of samples are presented in Table 3. Male respondents accounted for 52.38%. Since most young and middle-aged people in rural areas go out to work, the respondents were generally middle-aged and elderly, with more than 80% over the age of 40. The majority of respondents were engaged in agriculture, accounting for 88.64%. Respondents generally had a low education level, and nearly 90% of them had a middle school education or below. The average family size was 5.11.

The survey showed that the average cultivated land per person was 0.096 hm^2 and the average garden plot per person was 0.021 hm^2 before their relocation, but they were 0.040 hm^2 and 0.003 hm^2, respectively, after the relocation. The current status of land redistributed by migrants is shown in Figure 2. The annual agricultural income of migrant families accounted for 67.56% of the total income before relocation but decreased to 20.02% after relocation. Of the surveyed migrants, 78.75% believed that housing conditions had been improved after relocation, while 56.41% were not satisfied with the land compensation policy, and 31.14% felt that their living standards had declined after land expropriation.

Table 3. Basic information on samples.

Variables		Population/Person	Percentage/%
Gender of respondents	Male	143	52.38
	Female	130	47.62
Age of respondents	20–29	11	4.03
	30–39	33	12.09
	40–49	66	24.18
	50–59	82	30.04
	≥60	81	29.67
Occupation of respondents	Farmer	242	88.64
	Worker	15	5.49
	Merchant	3	1.10
	Others	13	4.76
Education level of respondents	Illiterate	45	16.48
	Primary school	88	32.23
	Middle school	110	40.29
	Senior high school	28	10.26
	Junior college and above	2	0.73

(**a**) plain area (**b**) mountain area

Figure 2. Land status after resettlement in the survey area.

3. Results

3.1. Calculation of Input Dividend Method

Combined with the relevant specifications, the operating period of the hydropower station was taken as 50 years. The construction period was taken as 10 years. According to the survey, the average area of land owned by households before relocation was 1.2 hm^2, while it was only 0.32 hm^2 after relocation, and the decline in natural capital and economic capital made it difficult for some migrants to recover their life and production [43]. In this paper, only revenue from power generation was considered and measured.

It was assumed that migrants would pay all the compensation for cultivated land and garden plot into shares, and the pricing ratio was 2.15% and 1.79%, respectively. The annual power generation of this hydropower station was 57.12 billion kWh, and the on-grid electricity price was 0.284 CNY/kWh in 2015 [10]. In the same year, the net interest rate of the hydropower industry was 29%, so the annual net income from electricity generation was 4704 million CNY as the initial annual revenue from the generation of operation. The depreciation or amortization of the project was taken into account in the electricity price formulation. The portion of the investment for migrants was amortized for 1.981 billion CNY, and it was amortized equally over 50 years with an average annual amortization

of 40 million CNY, including 22 million CNY for cultivated land and 18 million CNY for garden plots.

According to the global growth model, the average annual growth rate of China's GDP per capita from 2015 to 2050 is expected to be 4.38% [44]. Considering uncertainties, the annual earnings growth rate is conservatively estimated at 1% in this paper. The discount rate is generally calculated using the security interest rate and the risk-adjusted value. In this study, the safety rate is assumed to be the 10-year Treasury rate of 3.34% in 2015, and the risk-adjusted value is assumed to be 1%, based on both domestic and international experience in agricultural land valuation. Thus, the discount rate was set at 4.34%. Based on this, the compensation price (price in 2005) converted by the input dividend method for cultivated land and garden plot was calculated as (unit: CNY/hm^2)

$$P_{cultivated\ land} = \left\{ 47.04 \times 2.15\% \times \frac{\left(1 - \frac{1.01^{50}}{1.0434^{50}}\right)}{(0.0434 - 0.01)} + 0.22 \times \frac{\left(1 - \frac{1}{1.0434^{50}}\right)}{0.0434} \right\} \times \frac{\frac{10^8}{1.0434^{10}}}{3295.28} = 571,292 \quad (3)$$

$$P_{garden\ plot} = \left\{ 47.04 \times 1.79\% \times \frac{\left(1 - \frac{1.01^{50}}{1.0434^{50}}\right)}{(0.0434 - 0.01)} + 0.18 \times \frac{\left(1 - \frac{1}{1.0434^{50}}\right)}{0.0434} \right\} \times \frac{\frac{10^8}{1.0434^{10}}}{1355.55} = 1,153,150 \quad (4)$$

3.2. Calculation of Value Summation Method

3.2.1. Agricultural Use Value

The agricultural value is generally calculated by the income capitalization approach, whose calculation formula is

$$P_{agriculture} = a \times \frac{\left[1 - \left(\frac{(1+h)^n}{(1+r)^n}\right)\right]}{(r-h) \times (1+r)^k} \quad (5)$$

where a is the annual net income of agricultural land, h is the income growth rate, r is the capitalization rate, n is the term of land usage, and k is the average number of years from the time of investigation to the time of relocation, taken as 6 years.

According to the survey, the annual net income of cultivated land of migrant families was 10,528 CNY/hm^2, and that of the garden plot was 16,035 CNY/hm^2. The term of agricultural land use is consistent with the operation period of the project (50 years). This paper takes 3.25% of the 10-year Treasury rate in 2010 as the safe interest rate. The risk-adjusted value is taken as 1% with reference to similar research, and the land capitalization rate is set at 4.25%. With a boost in agricultural development, the returns on the output of agricultural land will trend up. From 2010 to 2015, the actual annual growth rate of agricultural added-value in Hubei and Henan provinces was about 4.5%, with a decreasing trend. In this paper, h was conservatively estimated at 1%. Based on these values, we calculated that the agricultural use value of cultivated land was 200,559 CNY/hm^2, and that of the garden plot was 305,467 CNY/hm^2.

3.2.2. Social Security Value

The social security value of agricultural land can be calculated by alternative methods and adjusted dynamically [45,46]. The calculation formula is:

$$P_{social\ security} = P_{employment\ security} + P_{old-age\ security} + P_{medical\ security} \quad (6)$$

where $P_{employment\ security}$ is the value of employment security, $P_{old\text{-}age\ security}$ is the value of old-age security, and $P_{medical\ security}$ is the value of medical security.

After losing their land, rural migrants often struggle to obtain relatively permanent jobs due to their limited human capital and lack of social capital. Therefore, it is advisable to measure the employment security value of agricultural land with the minimum subsistence allowance. In 2010, the minimum subsistence allowance for urban residents in the

Danjiangkou Reservoir area was 180 CNY per person per month, namely, 2160 CNY per person per year. According to the census data in 2010, the average age of the population in the reservoir area was 37 years old, and males accounted for 51.44%. Generally, the period of basic livelihood guarantee lasts until the farmers have essentially lost their labor, which is when males and females reach the ages of 60 and 55, respectively. Therefore, the number of years of guarantee was chosen to be 23 (for males) and 18 (for females). The calculation formula for the employment security value is:

$$P_{employment\ security} = 2160 \times \left\{ 51.44\% \times \left[1 - \frac{(1+e)^{23}}{(1+r)^{23}} \right] / (r-e) + 48.56\% \times \left[1 - \frac{(1+e)^{18}}{(1+r)^{18}} \right] / (r-e) \right\} \times b/q \quad (7)$$

where e is the average annual growth rate of the minimum subsistence allowance; r is the capitalization rate, taken as 4.25%; b is the proportion of agricultural income to household income before land acquisition; and q is the area of cultivated land and garden plot per person.

From 2010 to 2015, the actual annual growth rate of the minimum subsistence allowance in Hubei and Henan was approximately 8%, which was conservatively estimated at 2% in this paper. The value of the employment security of agricultural land was calculated as 199,947 CNY/hm^2. The social security function of agricultural land can be shared by the garden plot and the cultivated land. The weighted net income of agricultural land was 11,516 CNY/hm^2. Assuming that the net income is proportional to the security value, the employment security value of cultivated land was 182,786 CNY/hm^2, and that of the garden plot was 278,398 CNY/hm^2.

According to the provision of the residents' basic endowment insurance in China, a person's monthly pension is equal to the sum of their personal account balance divided by 139 and the basic pension, 139 being the number of months usually issued. The value of old-age security of agricultural land is calculated by taking the starting value equal to the minimum living security of urban residents at that time. In 2010, the basic pension of counties and cities in the Danjiangkou Reservoir area was 55 CNY per person. In order to simplify the calculation, assuming that the annual growth rate of the basic pension and the minimum subsistence allowance is equal, the calculation formula of pension payment, namely the value of pension security, is as follows:

$$P_{old-age\ security} = \left[\frac{51.44\% \times (180-55) \times (1+e)^{23}}{(1+r)^{23}} + \frac{48.56\% \times (180-55) \times (1+e)^{18}}{(1+r)^{18}} \right] \times 139 \times b/q \quad (8)$$

where e, r, b, and q are the same as the values in the above formula for the value assessment of the employment security.

It is not difficult to calculate that the pension security value of agricultural land would be 64,141 CNY/hm^2. In the same way, the pension security value of cultivated land and the garden plot are 58,636 CNY/hm^2 and 89,307 CNY/hm^2, respectively.

According to the provision of basic medical insurance for residents in China, every farmer in Danjiangkou county and city paid 30 CNY in 2010, which was coordinated by the government. During the same period, the average life expectancy in the reservoir area was 73 years, so the average payment time for farmers was 36 years. The calculation formula for the value of medical security of agricultural land is

$$P_{medical\ security} = 30 \times \left[1 - \frac{(1+t)^{36}}{(1+r)^{36}} \right] / (r-t) \times b/q \quad (9)$$

where t is the average annual growth rate of medical payment, and the values of r, b, and q are the same as those in the above pension security value evaluation formula.

From 2010 to 2015, the actual annual growth rate of farmers' medical payment in Hubei and Henan was about 15%, conservatively estimated at 2% in this paper. According to the calculation, the medical security value of agricultural land was 4189 CNY/hm^2,

while the medical security value of cultivated land and garden plots were 3830 CNY/hm^2 and 5833 CNY/hm^2 respectively.

To sum up, the social security value of cultivated land was 245,252 CNY/hm^2 and that of garden plot was 373,538 CNY/hm^2.

3.2.3. Value-Added Income Distribution

The Contingent Valuation Method (CVM) is adopted to investigate the purchasing intention of migrants to benefit from the right of land development, which is taken as the average value added. Then the value-added income of migrants is obtained by combining the distribution ratio. There is no subdivision of cultivated land and garden plot, and agricultural land is surveyed generally. According to the survey, the average annual willingness to pay is 27,435 CNY/hm^2. The calculation formula for migrants' participation in the value-added income distribution is

$$P_{value-added} = d \times f \times \frac{\left[1 - \frac{(1+h)^n}{(1+r)^n}\right]}{(r-h) \times (1+r)^k} \quad (10)$$

where d is the average value of willingness to pay at the time of the survey, h, r, n, and k are consistent with the values in the above agricultural use value evaluation formula, and f is the distribution ratio of migrants.

Regarding whether migrants should benefit from land appreciation, 90.84% of the respondents considered themselves contributors to the reservoir project and took for granted their participation in sharing. When respondents were further asked about the expected distribution ratio of the value-added income, the average response was 28.19%. This paper considers the positive and negative opinions and sets the distribution ratio of migrants as 25%. It was then easy to calculate that the migrants distributed 130,659 CNY/hm^2 in value-added income.

3.2.4. Land Compensation Price

The compensation for land expropriation of cultivated land and garden plots (price in 2009) were 576,470 CNY/hm^2 and 809,664 CNY/hm^2 respectively, as shown in Table 4 (unit: CNY/hm^2). The annual output value of the garden plot is higher than that of the cultivated land, so the agricultural use value and social security value of the former are higher than the latter. However, both are converted from agricultural use to reservoir use, so their value appreciation is the same.

Table 4. The calculation results of land compensation price.

Categories	Agricultural Use Value	Social Security Value	Value-Added Income Distribution	Total Value
Cultivated land	200,559	245,252	130,659	576,470
Garden plot	305,467	373,538	130,659	809,664

3.3. Comparative Analysis of Calculation Price and Policy Compensation

The input dividend method is characterized by simple calculations and few and accessible required parameters. This method is mainly suitable for hydropower projects with long-term stable income. The value summation method has broad applicability, is not constrained by the purpose of the land expropriation project, and can also be converted into installment payments based on the equivalent value of the funds. However, the data requirements are higher, and the measurement process is more complicated in the value summation method. Therefore, it is mainly suitable for water conservancy projects of quasi-public or public welfare.

The amount of policy compensation related to land obtained by reservoir migrants can be divided into early compensation and later support in China. Early compensation is

the one-time land compensation amount when migrants are relocated. Later support refers to the cash grant of 600 CNY per capita for 20 years after the relocation. The later support policy for reservoir resettlement is a characteristic policy of China. It has similarities and differences with social security. The formula for calculating the discount value is

$$P_{cash\ grant} = 600 \times \frac{\left[1 - \frac{1}{(1+i)^{20}}\right]}{i \times q} \quad (11)$$

where $P_{cash\ grant}$ is the present value of the cash grant, q is the area of cultivated land and garden plot per person, and i is the discount rate or capitalization rate.

The discounted value of the cash grant for migrants of Xiluodu Hydropower Station and Danjiangkou Reservoir are 89,660 CNY/hm^2 and 68,176 CNY/hm^2, respectively. Land compensation prices measured by the above two methods were compared with the actual policy compensation standard, as detailed in Table 5 (unit: CNY/hm^2). It is clear that the actual early compensation price of cultivated land and garden plots in Xiluodu Hydropower Station are 42.50% and 42.52% lower than the measured value, and even when added to the later cash assistance, they are still 26.81% and 34.74% lower. The actual early compensation price of the cultivated and garden plot in Danjiangkou Reservoir is 39.59% and 33.25% lower, respectively, than the estimated value. Even with the later cash grant, they are still 27.76% and 24.83% lower.

Table 5. Comparisons of compensation: calculated results and actual compensation.

Project	Categories	Calculated Price by Input Dividend Method	Calculated Price by Value Summation Method	Actual Early Compensation	Early Compensation and Later Cash Grant
Xiluodu Hydropower Station	Cultivated land	571,292	-	328,485	418,145
	Garden plot	1,153,150	-	662,867	752,527
Danjiangkou Reservoir	Cultivated land	-	576,470	348,240	416,416
	Garden plot	-	809,664	540,480	608,656

3.4. Optimization of Benefit Distribution

The above two cases analyses show that the land of migrants is generally reduced. The compensation is insufficient after resettlement, and reservoir migrants have not fully enjoyed the benefits brought by land appreciation. The livelihood transformation of some migrants is difficult. By adjusting the benefit distribution, the relatively balanced allocation of interests can be realized, the sustainable livelihood of migrants can be reconstructed, and the social risk can be minimized. According to the quantitative results, Xiluodu Hydropower Station may need to boost land compensation by a total of 1.465 billion CNY, equivalent to 2.91% of the total project investment, if additional compensation is to be made based on the existing compensation to increase the income of migrants. Funds can be arranged from power generation income. Danjiangkou Reservoir may need to increase land compensation by 3.997 billion CNY, equivalent to 1.74% of the total project investment. Funds can be arranged from water supply income, etc. In fact, after relocation, governments or development enterprises usually invest in migration assistance funds to prevent social risks, so it can be considered that the additional compensation value of the two cases are within the acceptable range and are reasonable and practicable. Governments should increase investment mainly around hardship allowance, employment support, education and training, medical assistance, endowment insurance, environmental improvement, cultural life, and other aspects to improve the sense of happiness and gains of migrants. Development enterprises are encouraged to fulfill their social responsibilities and share the benefits of development with migrants actively through industrial project support,

cultural and health project construction, infrastructure improvement, education donation, and caring for vulnerable groups.

In addition, a fair and reasonable land value-added income distribution system should be established to ensure the benefits that migrants deserve in the future. There are two possible ways of improvement: one is to raise the standard of land compensation directly without changing the existing compensation framework; the other is to change the existing compensation policy of land expropriation so that the compensation standard gradually inclines to the market price. That is, the compensation price can be calculated based on the quantitative method in this paper and determined through negotiation between land expropriation unit and migrants.

4. Discussion

The ideal model based on benefit sharing in resource development has its merits but is challenging to implement in practice. One of the main reasons is the lack of quantitative tools for the equitable distribution of benefits. The two methods in this paper consider the time value and risk of funds and the fair distribution of land appreciation. The calculated results are the reasonable compensation that migrants should receive, fully reflecting the concept of benefit sharing, such that the implementation of benefit-sharing systems has a quantitative basis for reference. Chen et al. established a benefit allocation model for hydropower development based on dynamic revenue [10]. Taking Xiluodu Power Station as an example, they concluded that if the core stakeholders were treated equally and received equal returns from the project, the total amount of additional long-term compensation for migrants (the gap between reasonable compensation and policy compensation) would be 1.363 billion CNY, which is similar to the estimated result (1.465 billion CNY) in this paper. The economic value, social security value, social stability value, and ecological environment value of the expropriated farmland of Xiluodu Project were calculated, and the total comprehensive functional value was 1,070,685 CNY/hm^2 [34]. The quantitative results of this paper are not significantly different from it. There is a lack of such research on Danjiangkou Reservoir of the South to North Water Diversion Project. Li et al. used the sum of basic life security, employment security function, old-age security function, and medical security function values to calculate land compensation. The analysis showed that the actual compensation price for Xiangjiaba Project migrants was lower than 33.24% of the value calculated by the value summation method [45]. Chen et al. believes that the fair land compensation price of migrants should include its market value and non-market value. Taking the Zaoshi Water Conservancy Project as an example, it was estimated that the current compensation standards for paddy field and dry land were 46.23% and 46.20% lower than the fair compensation prices, respectively [47]. The ratio of policy compensation to reasonable compensation showed little difference with the Danjiangkou Reservoir research results (39.59% and 33.25%). All these further prove the rationality of the calculation methods in this paper. Compared with previous methods, the calculation methods proposed in this paper may more directly reflect the distribution of land value-added benefits, so they are relatively easier to be accepted by all parties. If current policies are improved, migrants will benefit more from projects that raise their productivity and living standards and may in turn support the development of water resources.

Some research data are challenging to collect: flood control and other non-financial benefits are still not quantified, and the economic benefits of the project are uncertain. The subjective evaluation of migrants may lead to bias in the survey results. Although there may be some deviations in the calculation findings, they can at least provide an economic reference for improving land compensation standards. The pricing of land compensation is very complex. The accuracy of calculation results will be significantly impacted by the reasonableness of the parameters in the methods. Methods to determine parameters scientifically and to improve data collection accuracy are worth exploring further. Even if reasonable compensation for migrants is calculated using the input dividend method, it does not mean that the stockholder resettlement can be realized. Only a few

local small hydropower projects in China have adopted this resettlement. Few other countries or regions have the practice of stockholder resettlement. It is hard to expect much improvement in the future. The willingness and views of governments, enterprises and other stakeholders on benefit sharing are also worthy of investigation and analysis. Due to fund limitations, this paper only focuses on land compensation related to the Xiluodu Hydropower Station and Danjiangkou Reservoir of the South to North Water Diversion Project. However, there are variations in the land expropriation of migrants in various periods or countries. The universality of the calculation methods for land compensation reflecting benefit sharing needs to be verified by more examples. Multiple methods can also be attempted for comparative analysis. Policy improvement measures also require in-depth exploration and continuous practice.

5. Conclusions

The construction of water conservancy and hydropower projects has become the reliable support and strong guarantee for flood control security, food security, ecological security, energy security, water supply security, etc., and continues to shoulder the heavy responsibility of achieving modernization and dual carbon goals in China. However, it has faced two major tests of environmental protection and resettlement. Benefit sharing emphasizes the sustainable use of resources and the fair distribution of benefits. As the main stakeholders of water conservancy and hydropower projects, benefit sharing is the natural right of migrants and is also in line with the development concept of joint construction, sharing, and win-win. Fair and reasonable compensation for land expropriation should compensate migrants not only for the value of their existing use of agricultural land, but also for potential social security and development benefits so that migrants can fully enjoy the benefits of land appreciation. This paper presents specific quantitative methods and case analyses of reasonable land compensation under the participation of migrants in benefit sharing. The results show that the calculated price of the input dividend method and the value summation method are both higher than the actual compensation amount, which means that reservoir migrants are not fully involved in the process of benefit distribution of water conservancy and hydropower development under the current compensation policy. The input dividend method is mainly suitable for hydropower projects with stable returns, while the value summation method is mainly suitable for water conservancy projects with lower economic returns. The cases prove the rationality and operability of the calculation methods to some extent. In short, this paper forms a necessary supplement to traditional qualitative and descriptive benefit-sharing and equitable compensation research and also strengthens the guiding significance for project practices.

From now on, water conservancy and hydropower projects may face a more complex natural and human ecological environment due to increased uncertainty, and resettlement without soil or with less soil will make migrants face opportunities and challenges for livelihood transformation, so an equal distribution of benefits is crucial for sustainable development of the water resources. It is suggested that the compensation for land expropriated for new reservoirs can refer to the value summation method or the input dividend method, and should be determined through negotiation between migrants and governments and enterprises. The compensation standard should be appropriately raised to permit migrants to fully enjoy the achievements of water resource development, and diversified ways such as one-time compensation or long-term compensation may be adopted according to local conditions so as to create a new situation of co-construction, sharing, and win-win. In addition, for the reservoir projects that have already been built, additional monetary or non-monetary follow-up support can also be provided according to the calculation results of the two methods to optimize the distribution of benefits, better ensure the long-term livelihood of migrants, avoid social risks, promote sustainable development of water conservancy and hydropower, and achieve a win-win situation of resettlement and project construction.

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