Evaluation on the willingness of migrants and native farmers to transfer farmland in resettlement areas and their coupled coordination relationships: perspectives for environmental and social sustainability

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The construction of water conservancy and hydropower projects often involves substantial land acquisition and resettlement. Land is a crucial means of production, playing a significant role in ensuring food security and protecting the ecological environment and social development. However, the advancement of urbanization and changes in production methods have led to a noticeable shift in the behavior of farmers on lands. Abandoned land and reclaimed wasteland in host resettlement areas lead to low land-use efficiency, environmental degradation, and frequent geological disasters. It is important to evaluate the willingness of migrants and native farmers to transfer farmland in the resettlement area and their coupled coordination relationships to realize effective land use. These were evaluated in this study by constructing an index system from personal and family characteristics, land resource endowment, characteristics of the external policy environment, and psycho−cognitive characteristics. The results showed that their coupling degree was 0.999, while their coupling degree of coordination was 0.68. The relative development degree was 1.01. It showed that a strong correlation existed between the willingness of migrants and native farmers, and they were in a basic coordination phase. They influenced each other and reached a basic balanced state. Farmland can be transferred between migrants and native farmers to improve their livelihood, resettle migrants, improve land-use efficiency, and reduce wasteland reclamation. This suggested the possibility of establishing a land transfer resettlement model based on the willingness of migrants and native farmers to achieve environmental and social sustainability in the resettlement area.
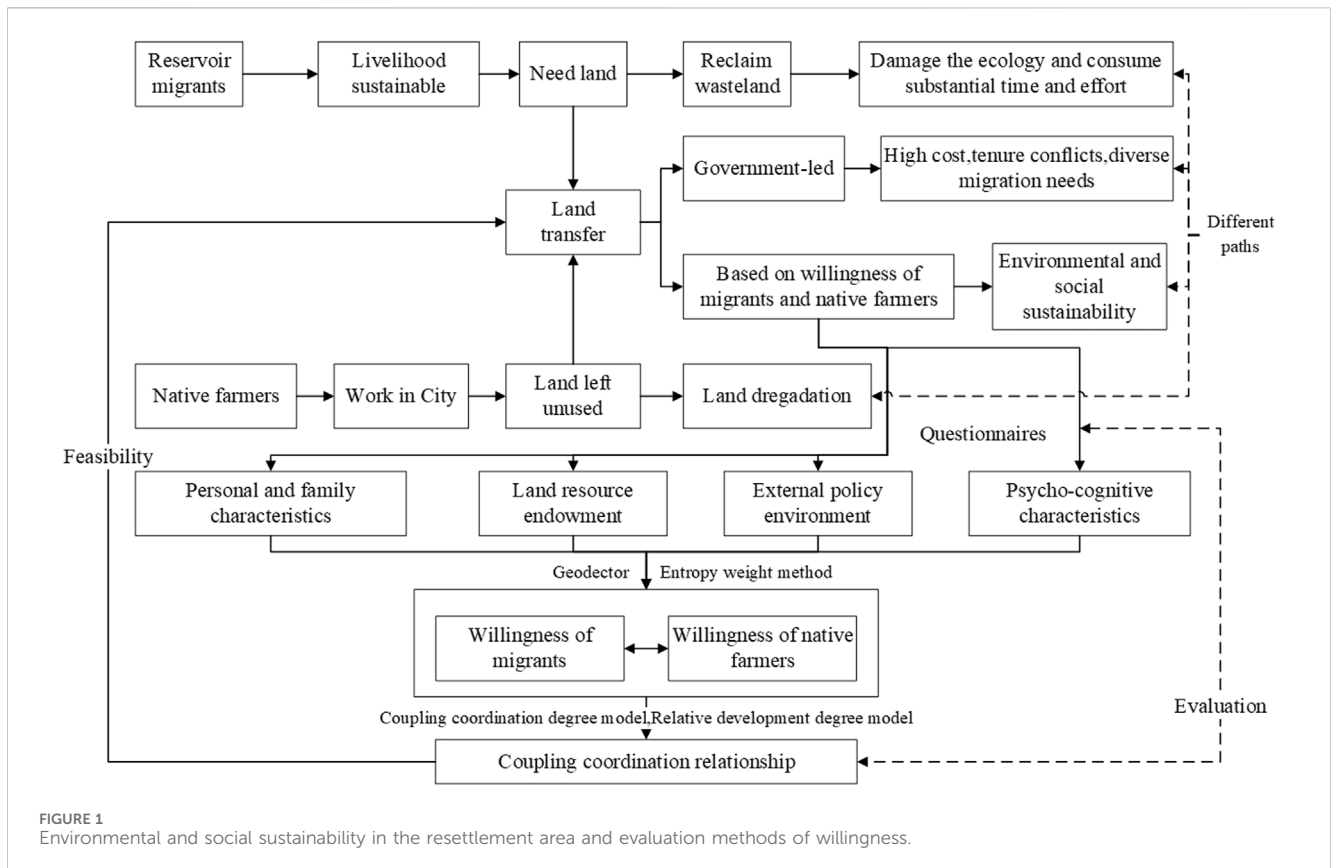
1 Introduction

Land holds paramount significance in the agricultural sector, serving as the gateway for individuals to access a myriad of assets and opportunities (Lastarria-Cornhiel, S et al., 2014). Findings from the Third National Land Survey indicate that as of the end of 2019, China possessed an arable land area that totals to 1.27 billion ha, equating to a *per capita* arable land area of merely 0.09 ha—less than 40% of the global average (Guangming Daily, 2022, June 26). Given the relative scarcity of China's arable land resources, the nation places significant emphasis on the sustainable utilization of land. Over an extended period, China has implemented dual-land systems, differentiating between urban and rural areas. Urban land is state-owned, whereas rural land is under the ownership of collective economic organizations, and neither urban nor rural land is subject to buying or selling. With the ongoing expansion of China's urbanization and the escalating allure of cities, an increasing number of farmers are migrating to urban areas in pursuit of elevated incomes and improved living conditions. This has resulted in an insufficient labor force for cultivating rural lands, leading to a significant depletion of the countryside, abandonment of substantial land areas, and inefficient land utilization. In 2014, China initiated a gradual reform of the rural land system, known as the three-rights division. Rural land is now divided into three components: land ownership, land contracting rights, and land management rights. In this context, rural land ownership remains collective, allowing farmers to enter land contracts and transfer land management rights to third parties. This implies that, under specific conditions, farmers have the option to lease their land, exclusively for agricultural purposes. The purpose of this reform is to promote land transfer and enhance the efficiency of land utilization. Nevertheless, in practical terms, economically disadvantaged regions face challenges as their land is fragmented and unproductive, with individual farmers owning small plots, making it challenging for them to engage in land transfers. In these regions, a majority of farmers either gift their land to friends and relatives when migrating for work or simply let it lie fallow, resulting in land degradation.

By 2021, China had built more than 98,000 reservoirs, including the world-famous Three Gorges Dam. Numerous hydroelectric projects have generated a large number of reservoir migrants. Reservoir migrants are involuntary migrants, who have had to be resettled because their land has been occupied, flooded, submerged, or experienced a landslide as a result of reservoir construction. It is suggested that the number of people displaced by large dams is between 40 and 80 million worldwide (Scudder, T, 2005), and China had generated more than 25 million migrants (People's Daily, 2022, October 27). The migration issue is directly related not only to the smooth construction of water conservancy and hydropower projects but also to the immediate interests of migrants and social stability (Chen S et al., 2014). The World Bank has proposed "land resettlement" or land-for-land compensation for migrants with respect to the land they lose in water conservancy and hydropower projects, aiming to ensure that migrants' living standards are not reduced and that their long-term livelihood is guaranteed. "Land resettlement" is generally considered to be a resettlement method that should be prioritized (Heming L et al., 2001). The way to obtain compensated land is usually to reclaim

reserve land resources or levy and deploy surplus land in the resettlement area (Shi G et al., 2008). However, in reality, because of the shortage of arable land in reservoir areas and the limitations of environmental capacity, migrants usually move to resettlement areas to obtain land resources through government-led deployment (Xu J et al., 2015). Due to limited land resources, coupled with the increasing awareness of farmers' land value appreciation, the "passive transfer" of land in such resettlement areas is often not only difficult but also leads to acute tenure conflicts between the government and farmers or migrants and farmers (Chen Y et al., 2011). In addition, in some areas, the government paid high prices to acquire land for the resettlement of migrants, but the migrants transferred out of most of the land and work in cities resulting in a great waste of resources (Zhao X et al., 2018). With the continuous promotion of urbanization and urban–rural integration, increasingly more farmers' dependence on land is decreasing, and the demand for land transfer in and out is not equal, resulting in the waste of idle rural land resources; moreover, some reservoir migrants are poor due to the lack of land resources (Li G et al., 2022). Certain landless migrants find themselves compelled to undertake land reclamation activities. Nevertheless, the process of land reclamation proves to be both time-consuming and labor-intensive, presenting challenges in securing the livelihoods of migrants. Furthermore, it inflicts damage upon the ecological environment and precipitates local geological disasters.

Thus, achieving environmental and social sustainability in resettlement areas hinges on fostering the willingness of migrants and native farmers to engage in land transfer (Figure 1). This facilitates the effective utilization of existing land, minimizes the need to open new migrant land, and ensures the safeguarding of migrants' livelihoods. It is necessary to establish an index system to evaluate the willingness and the coupling coordination relationship of migrant and native farmers to transfer land.

Current research on the factors influencing the willingness to transfer farmland is generally based on ordinary farmers; it is believed that age, gender, family, industrial, and commercial capital are important to the countryside (Li G et al., 2022); family structure (Zhang Z et al., 2019); physical health; life cycle (Li J and Nie J, 2019); land prize (Dominika M, 2018); land transfer taxes (Joshua M, 2004); and state pensions (Duesberg, Stefanie et al., 2017). Land tenure (Charles C. Krusekopf, 2002), trust in the government (Pu S and Yuan W, 2018), purpose of farming (Huang W et al., 2017), household income (Songqing J, Thomas S 2013), risk (Markus G, 2011), farmer cognition, market capacity, and degree of activeness (Cheng X, Huang H, 2016; Teng P et al., 2017) all have significant impacts on the willingness of farmers to transfer out of farmlands. Overall, the willingness of ordinary farmers to transfer in is low while that to withdraw is high (Zhong Z, Hu M, 2018). Migrants are separated from ordinary farmers in terms of resettlement, social network relations, and livelihood, and farmers in resettlement areas also have the problem of recognizing and trusting migrants compared to ordinary farmers; therefore, it is difficult to apply research on ordinary farmers to migrants and native farmers in resettlement areas. However, little attention has been paid to migrants and resettlement area farmers; Chen S et al. (2022) found that family characteristics, financing opportunities, and the radius of transferring farmlands have significant effects on migrants'

FIGURE 1
Environmental and social sustainability in the resettlement area and evaluation methods of willingness.

willingness to transfer in to farmlands. Chen Y et al. (2011) reported that the number of years of education, the number of family laborers, and the share of agricultural income had an effect on the land transfer intentions of farmers in resettlement areas, while the total number of family members and the number of people in agriculture had a nonsignificant effect. Liu L (2015) reported that age, gender, *per capita* household contracted land, total household income, reduction in *per capita* household contracted land, and group-wide adjustment mode had significant effects on the willingness of native farmers to share land with migrants from the perspective of land property rights. However, these authors did not conduct further research on the relationship between migrants' and native farmers' willingness to transfer farmlands. In terms of research methods, research on the factors influencing the willingness to transfer land is dominated by the questionnaire survey method, logistics model, structural equations (Zhang Z et al., 2019), and other methods of analysis; however, these methods have difficulty solving the problem of nonlinearities, and they are more sensitive to data multicollinearity. Research on the factors influencing the willingness of migrants to transfer in to farmlands and the willingness of native farmers to transfer out of farmlands and their coupling and coordination relationships can help determine the demand of migrants and native farmers for holding land to adopt corresponding resettlement methods, which is highly important for maintaining the stability of the social environment in the resettlement area and guaranteeing the livelihood of migrants.

In view of this, this paper takes the Guizhou PQ Reservoir project as an example, adopts the Geodetector model, analyzes the willingness of migrants to transfer in to farmlands and willingness of native farmers to transfer out of farmlands to influence the factors, and uses the entropy weight method and the coupling degree of the coordination model to further evaluate the coupling and coordination relationship between the migrants and native farmers to not only improve the theory of resettlement but also provide the basis for innovation in relation to land transfer and resettlement mechanisms and achieve environmental and social sustainability.

2 Study area

Due to its geographic characteristics, large-scale water conservancy and hydropower project construction has been carried out Guizhou Province, resulting in a large number of migrants. The PQ Reservoir is located in Anlong County, Qianxinan Prefecture, Guizhou Province (Figure 2). This area is a rocky desertification area, with a large inundation area and insufficient land capacity in the reservoir area. Migrants have adopted the mode of centralized agricultural resettlement within the county, and it is difficult for the government to unify the transfer of land due to a large number of problems. Most of the original residents of the resettlement area have gone out to work, and the farmland is idle, with many households willing to turn over the land. There are many farming households. A total of 234.7 ha of cultivated land is affected by land acquisition for the construction of the PQ reservoir project, and after acquisition, the remaining cultivated land in the affected villages and groups is mostly poor-quality sloping and dry land. Fork River village and Longxin village, which have been affected by the

FIGURE 2
Location of the PQ Reservoir.
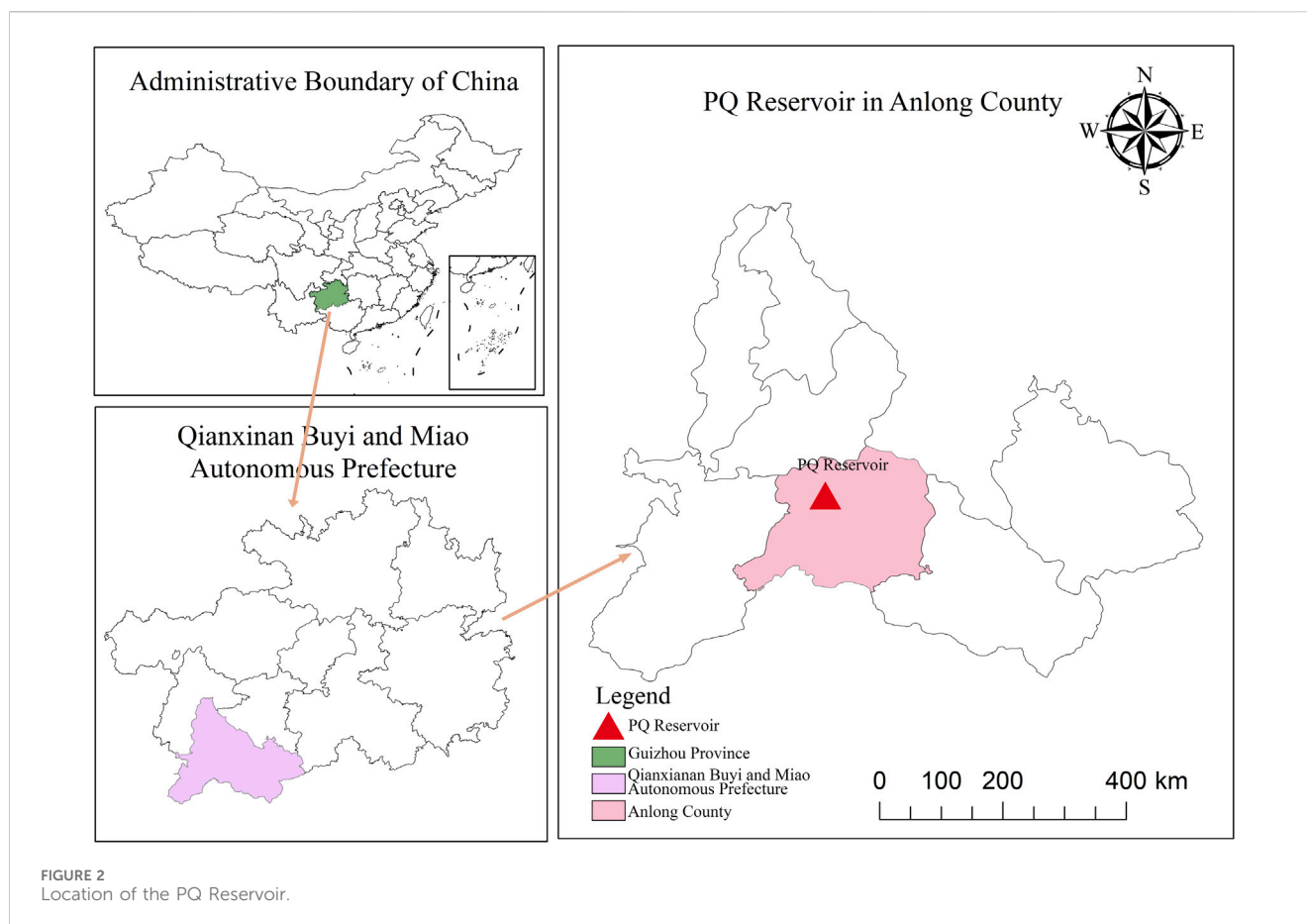
construction of the PQ reservoir, are mainly resettled into three resettlement sites involving two townships in Anlong County, namely, the Liangtai resettlement site, Shiyakou resettlement site, and Qianxiang resettlement site. The three resettlement sites are close to each other, and the resettlement sites and the original residences are also close to each other; they are situated in the same county and have the same socioeconomic conditions. They are all located on both sides of the main road in towns and cities. They have convenient transportation and rich land resources and similar qualities. The villages and groups of land available for transfer selected near the three resettlement areas are as follows: Yangdi village and Xiangchehe village near the Liangtai resettlement area in Gotang township, with 14,138.52 acres of existing cultivated land; Qianxiang village, Qiaoma village, and Sandaowang village near the Xiaoqian Jiang resettlement area in Qianxiang township, with 8,300.73 acres of existing cultivated land; and Huxiang village and Xinjie village near the Shiyakou resettlement area in Puping township, with 543.97 ha of existing cultivated land. The total amount of arable land resources in the three resettlement areas is 2,039.92 ha.

PQ Reservoir area belongs not only to the poverty-stricken area but also to the key zone of rural revitalization; thus, the resettlement of reservoir migrants can be combined with market-oriented land transfer to solve the resettlement problem of migrants, which also helps enrich the study of the land resettlement problems of migrants.

3 Data sources and research methodology

3.1 Data sources

The data for this study were obtained through field research conducted by the research group in May 2021, December 2021, and July 2022, focusing on three centralized migrant resettlement areas around the PQ Reservoir in Anlong County. This study investigates the willingness of reservoir migrants to transfer in to farmland management rights and native farmers in resettlement areas to transfer out of farmland management rights. To ensure the typicality and representativeness of the research data, the study used a sampling survey and conducted household interviews, focusing on migrants and native farmers at the three resettlement sites and the seven villages adjacent to these sites. The seven villages were Yangdi village and Xiangchehe village in the Liangtai resettlement area of Getang township; Huxiang village and Xinjie village in the Shiyakou resettlement area of Puping township; and Qianshang village, Qiaoma village, and Sandaowu village in the Xiaoxian resettlement area of Qianshang township. The survey commenced with structured interviews of the PQ Reservoir immigration project office personnel and village cadres from the resettlement areas to gain insights into the local situation. Subsequently, household interviews were conducted with a random sample of residents from the three migrant resettlement

areas to complete the survey questionnaire. Initially, 300 questionnaires assessing the willingness of migrants were distributed, which resulted in the recovery of 250 questionnaires. After excluding incomplete and landless migrants' responses, 226 valid questionnaires were obtained, yielding a validity rate of 75.33%. A total of 158 households were willing to transfer in to farmlands, while 68 households were unwilling to do so. A total of 300 questionnaires assessing the willingness of native farmers were distributed, resulting in the recovery of 250 questionnaires. After excluding incomplete and landless migrants' responses, 213 valid questionnaires were obtained, yielding a validity rate of 71%. A total of 148 households were willing to transfer out of farmlands, while 75 households were unwilling to do so.

3.2 Theoretical framework and research method

3.2.1 Mechanism of the coupling coordination relationship

In coupling, two or more systems influence each other by acting on each other. The degree of coupling coordination can reflect whether the systems are good, as well as the relationship between the systems that are harmonized and interact with each other. The transfer of farmlands is not only conducive to restoring the livelihood of migrants but also helps reduce land abandonment and improve the efficiency of land resource utilization. According to the assumptions of "rational man" and "economic man," individuals always attempt to and can judge how to choose the course of action that is beneficial to them. On one hand, migrants and farmers, as rational actors, pursue the maximization of economic smallness. On the other hand, while pursuing the maximization of economic benefits, they also have to consider the basic life security attached to farmland; they also need to take into account the functional value of the basic life security, employment, old age, medical care, etc., attached to farmlands (Wu Y et al., 2016). Although farmland transfer willingness is based more on migrants and farmers themselves and on the influence of external environmental conditions under limited rational judgment (Yang J, Long Z, 2019), when rural land is transferred as a market, farmland transfer is also willing to influence each other. Migrants need to transfer in to farmland to hedge the risk to meet the needs of their family livelihood; thus, when the willingness of migrants to transfer in the farmland is strong enough, the farmland rent increases, which can stimulate the willingness of native farmers to transfer out the farmland. When the family members of native farmers leave for work, the family agricultural labor force becomes insufficient. Thus, native farmers need to appropriately transfer part of the land to avoid land abandonment and to obtain a land rent that achieves the maximization of benefits. When native farmers are willing to transfer out of a strong enough area, then, the farmland rent decreases, stimulating the willingness to transfer to migrant farmlands. When they reach a balanced state, migrants can transfer to the land to improve their livelihoods, and the residents of the resettlement area can also improve their income, so that both sides can maximize their benefits, while the land resources are also fully utilized.

In view of this, through literature review and field research, this paper divides the influencing factors affecting the willingness to transfer farmland into four parts—personal and family characteristics, land resource endowment, external policy environment characteristics, and psychological cognitive characteristics—of which 14 questions are designed in the questionnaire on the willingness of migrants to transfer in to farmlands, and 15 questions are designed in the questionnaire on the willingness of native farmers in the resettlement area to transfer out of the farmland, as shown in Table 1.

3.2.2 Research methods

1) Geodetector

The Geodetector analysis method is a program developed by Wang J et al. (2017) based on Excel. The core idea of this software is as follows: if an independent variable has a certain effect on a dependent variable, then this strain and this independent variable will show similar assumptions in spatial distribution. Geodetectors include four parts—a risk detector, factor detector, ecological detector, and interaction detector (Dong et al., 2017)—and have the advantages of no redundant assumptions, a relatively wide range of applications, good ability to handle the type of volume, ability to detect interactions between factors, immunity to multivariate covariate covariates, no linear assumption, and clear physical meaning (Xu Q et al., 2015). In this paper, we use a factor detector to analyze the influencing factors of the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland. The calculation formulas are as follows:

$$q = 1 - \frac{\sum_{h-1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST}, \tag{1}$$

$$SSW = \sum_{h-1}^{L} N_h \sigma_h^2, SST = N\sigma^2, \tag{2}$$

where $h = 1$; L represents the stratification of variable Y or factor X; N_h and N represent the number of cells in stratum h and the whole region, respectively; and σ_h^2 and σ^2 represent the variances of the Y values in stratum h and the whole region, respectively. SSW and SST represent the sum of the intrastratum variance and the total variance in the whole region, respectively. Q shows a value range of [0, 1], and a larger value indicates that the spatial differentiation of Y is more pronounced; if the stratification is generated by the independent variable X, then a larger value of q indicates that the explanatory power of the independent variable X on attribute Y is stronger. A larger value indicates that the explanatory power of the independent variable X for attribute Y is stronger and vice versa.

The interaction detector is used to analyze the influence of interactions between different factors on the willingness of migrants to transfer in to farmland or the willingness of native farmers to transfer out of farmland. The method has several advantages in that the assumptions about the interactions are not limited to traditional statistical methods. For a description of whether the interaction of the driving factors enhances or weakens the explanatory power of the analyzed variables, the related literature should be observed for additional details (Yang J, Long Z, 2019).

2) Entropy weight method

TABLE 1 Questionnaire for migrants and native farmers.

Question	Migrant	Native farmer
Personal and family characteristics	Age	Percentage of the household income from agriculture
		Age
	Number of family agricultural laborers	Number of family agricultural laborers
	Educational level	Educational level
	Whether to participate in pension and medical insurance	Whether or not owns a home in the town
	Level of nonfarm payrolls	Level of nonfarm payrolls
Land resource endowment	Land area before expropriation	Farmland area per household
	Value of farmland	Degree of farmland fragmentation
	Distance to transferred farmland	Whether there is unused land
Characteristics of the external policy environment	Financing opportunities	Nonfarm employment opportunities
	Farmland transfer organization	Farmland transfer organization
	Availability of agricultural skills training	
	Local non-farm employment opportunities	
Psycho–cognitive characteristics	Integration in settlements	Cognizance of the attribution of contractual rights after land transfer
		Knowledge of land transfer policies
	Knowledge of land transfer policies	Expected returns from land transfers
		Degree of concern about damage to land rights and interests
		Psychological perception of migrants

The entropy weight method is an objective assignment method that determines objective weights by measuring the degree of differentiation. The entropy weight method is simple and easy to use and can not only consider the correlation between the evaluation indicators but also consider the differences between the indicators at the same time, with wide applicability. In this study, the entropy weight method is used to assign weights to the influencing factors of land transfer willingness. The steps of the entropy weight method mainly include the following:

① Data standardization

$$X'_{ij} = \frac{X_{ij} - min\, X_{ij}}{max\, X_{ij} - min\, X_{ij}} + 0.0001, \quad (3)$$

$$X'_{ij} = \frac{max\, X_{ij} - X_{ij}}{max\, X_{ij} - X_{ij}} + 0.0001, \quad (4)$$

where X_{ij} and X_{ij}" denote the original and normalized values of the jth (i=1, 2, ..., m) sample for the ith (i=1, 2, ..., n) indicator, respectively, and $maxX_{ij}$ and $minX_{ij}$ denote the maximum and minimum values in the ith indicator, respectively.

② Data weight calculation

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X'_{ij}}, \quad (5)$$

$$E_j = -k \sum_{i=1}^{n} P_{ij} \ln P_{ij}, \quad (6)$$

$$k = \frac{1}{lnn}, $$
$$D_j = 1 - E_j, \quad (7)$$

$$W_j = \frac{D_j}{\sum_{j=1}^{m} D_j}, \quad (8)$$

where n represents the number of samples: $0 \ll E_j \ll 1$, when $P_{ij} = 0$, make $P_{ij} \ln P_{ij} = 0$. D_j represents the indicator entropy redundancy, and W_j represents the weight.

③ Comprehensive evaluation coefficient calculation of indicators

$$S_j = \sum_{j=1}^{m} W_j \times X'_{ij} \quad (9)$$

where S_j represents the comprehensive index.

3) Coupling coordination degree model

Coupling refers to the interaction of different systems under the influence of themselves and the outside world, and the degree of coupling coordination can reflect whether the systems have a good level of interaction or not, as well as the relationships between the systems that are harmonized and interact with each other (Ren B, Gong Y, 2022). This paper analyzes the coupling coordination degree model of the willingness of migrants to transfer in to farmlands and willingness of native farmers to transfer out of farmlands and analyzes its coupling coordination and

development relationship by constructing the coupling coordination degree model.

$$C_i = 2 \times \left[\frac{U_1 \times U_2}{(U_1 \times U_2)^2} \right]^2, \quad (10)$$

$$T_i = aU_1 + bU_2, \quad (11)$$

$$D = \sqrt{C \times T}. \quad (12)$$

In Eqs 10–12, C represents the degree of coupling, T represents the comprehensive coordination index, D represents the degree of coupling coordination, and U_1 and U_2 represent the standardized values of the evaluation indices of the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland, respectively. A and b represent the coefficients to be determined, and $a + b = 1$. In this paper, considering that migrant farmland transfer willingness and native farmer farmland transfer willingness play a comparable role in the farmland transfer process, the coefficient of determination is $a = b = 0.5$.

4) Relative development degree model

The coupled coordination model reflects the strength of the intrinsic link between the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland; however, it cannot reflect the gap between them. Therefore, the relative development degree model is introduced to measure the degree of overrun or lag between the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland. The formula is as follows:

$$P = \frac{U_1}{U_2}, \quad (13)$$

where P represents the relative development degree. Combined with the findings of this study, when $p > 1.2$, then migrant farmland transfer willingness is considered to be the overadvanced type; when $0.8 < p \leq 1.2$, then the development of land transfer of migrant and native farmers is to be simultaneous; and when $p \leq 0.8$, then the native farmers' farmland transfer is considered to be the lag type.

4 Evaluation

4.1 Analysis of influencing factors

4.1.1 Factor detection analysis

1) We use factor detector to analyze the influencing factors of the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland (Eqs 1, 2). Personal and family characteristics: Age, the education level, and the nonagricultural employment level have weak effects on the willingness of migrants to transfer in to farmland, while the number of family agricultural laborers has a significant effect on this variable, and the effect of participation in pension and medical insurance is not significant. A possible reason for this difference is that these insurances are not clearly perceived in the daily lives of migrants; rather, they play only a bottoming-out role in their lives and not a significant role in increasing their standard of living. Therefore, insurance is not taken into account when

transferring a means of production such as land. The older the migrants, the stronger their willingness to transfer in to land; this is because the older their skills and willingness to go out to work, the lower their willingness to use not only the function of production but also the social security functions that can be seen as the basis of the farmer's life. The greater the education level of migrants and the greater the level of nonagricultural employment, the lower the willingness to transfer in to farmland. Generally, the greater the education level, the greater the ability to engage in nonagricultural employment, the more diversified the employment methods, the more ways of obtaining economic income, and the less reliance on land; however, migrants transfer in land to satisfy their needs for livelihood, and obtaining land is the most direct way to let migrants stabilize. Thus, the desire to obtain land is much stronger than the desire for nonagricultural employment, and the desire to obtain land is much stronger than that of nonagricultural employment. Therefore, the desire to obtain land is much stronger than that of nonagricultural employment, which means that the influence of the education level and nonfarm income is relatively weak, and the larger the family agricultural labor force, the stronger the ability to engage in agricultural production, and the greater the demand for land. For the willingness of farmers in the resettlement area to transfer out of farmland, age has no influence, the education level has a weak influence, and the decision of farmers in the resettlement area to transfer out of farmland is more cautious, while the decision is generally made after discussion with the family; thus, age has no influence. For farmers in resettlement areas, the decision to transfer out of farmland is more prudent than for other farmers and generally has to be discussed by the whole family before a decision is made. In resettlement areas, farmers are generally willing to transfer land due to the increased publicity of the land transfer policy, and farmers with higher education levels are more willing to transfer their land for rent. Whether or not they own housing in towns has a weak effect as farmers generally do not transfer all of their land but rather keep some of it, which means that those who own housing in towns often return to take care of their land; therefore, there is an effect of owning a home in towns but to a lesser extent. The level of nonfarm employment and the number of agricultural laborers in the household have significant impacts. For native farmers, the purpose of granting land is to obtain land rent to obtain maximum income; the greater the level of nonfarm employment, the more diversified the employment methods, and the more economic income obtained; additionally, the lower the dependence on land is. Thus, the level of nonfarm employment can directly affect the willingness of native farmers to transfer out; furthermore, due to the lower income from farming, native farmers are more likely to prefer nonfarm employment, which means that the number of family farm laborers has a weaker impact on the transfer of land than that of migrants.

2) Land resource endowment: The number of land resources before land expropriation has a weaker impact on the willingness of migrants to transfer in to farmland, while the distance to the transferred farmland has a stronger impact on the value of the farmland. The more land resources there are

before land expropriation, the stronger the willingness of migrants to transfer into farmland; however, the primary goal of migrants at this time is to restore their livelihoods. Different migrants choose to work within or outside of agriculture according to their situation; thus, the land situation before land expropriation has little impact on them. On the other hand, the distance and value of the transferred farmland directly affect migrants' convenience in farming and the value of the crops they produce; therefore, these factors have a stronger impact. The degree of land fragmentation and the availability of idle farmland significantly impact the willingness of farmers in resettlement areas to transfer out of farmland. Under rational thinking, the greater the degree of land fragmentation, the greater the cost of engaging in agricultural production. Additionally, when engaging in saturated agricultural labor, whether by asking for help or working overtime by themselves, the cost of farming idle land is greater; thus, it is better to transfer the land to the farm. In the case of saturated agricultural labor, whether by hiring help or "overtime" labor, the cost of cultivating idle land is greater; thus, it is better to transfer it in exchange for land rent.

3) Characteristics of the external policy environment: The influence of farmland transfer organizations on the willingness of migrants and resettlement farmers to transfer farmland is not significant. The reason is that the procedure of rural land transfer is relatively mature; whether land is transferred under the guidance of the government or transferred without such help, farmers generally prefer to sign a contract and leave written evidence when transferring land. Thus, the influence of farmland transfer organizations is not significant. Local non-farming employment opportunities have a significant impact on the willingness of migrants and native farmers to transfer farmland, but the degree of impact is different. Native farmers are more affected by local non-farming employment opportunities. The reason for this is that although local non-farming employment opportunities can bring migrants work opportunities, on one hand, owning the land can enable migrants to better settle and integrate into the resettlement area, while on the other hand, migrants are "newcomers" and have a certain disadvantage in choosing to work locally compared to farmers in the resettlement areas under the same circumstances. For native farmers, the income from labor is greater than that from farming, and families can maintain part of the land to maintain food rations and transfer the remaining land to maximize economic benefits. Financing opportunities have some impact on the willingness of migrants to transfer in to farmland. The reason for this is that after migrants move and resettle to build houses, they do not have extra savings in their hands to devote to agricultural operation, and they lack start-up capital; however, if financing and lending opportunities are provided, migrants are more willing to engage in farmland management rights. Thus, whether planting and training in other skills are provided has a significant impact on the willingness of migrants to transfer in to farmland.

4) Psychological cognitive characteristics: The degree of understanding the land policy has an impact on the willingness of both migrants and native farmers to transfer land, but the difference in the degree of influence is significant. The degree of understanding the land policy has a strong influence on the willingness of farmers in resettlement areas to transfer out of farmland, while the influence on the willingness of migrants to transfer into farmland is very weak. The reason for this is that migrants transfer in to farmland to satisfy their livelihoods, while farmers in the resettlement areas transfer out of farmland to maximize economic benefits, as evidenced by the significant influence of land transfer revenue expectations and the degree of concern about damage to land rights and interest on the willingness of farmers in resettlement areas to transfer land. Community integration in resettlement areas has a significant effect on the willingness of migrants to transfer into farmland because farming is a long-term process that requires considerable time and energy; the greater the integration of migrants, the more willing they are to settle rather than return or move to other places, and the more willing migrants are to engage in land cultivation. The psychological perception of migrants has a significant effect on the willingness of native farmers to transfer land. The better the native farmers' psychological perception of migrants is, the more they trust migrants, the more willing they are to deal with migrants, and the more willing they are to transfer their land.

4.2 Analysis of the coupled coordinated relationship

This study used the entropy weight method based on the significant influencing factors to evaluate the willingness of immigrant farmers to acquire land and the willingness of native farmers in resettlement areas to transfer land. The weights of the influencing factors were obtained through Eqs 3-9. The weights of each factor are shown in Table 2. The evaluation index of the willingness of migrants to transfer in to farmland was 0.478, and the evaluation index of the willingness of native farmers to transfer out of farmland was 0.470; the results were obtained by substituting these values into Eqs 10–13, as shown in Table 3.

The coupling degree of the willingness of migrants to transfer in to farmland and willingness of native farmers to transfer out of farmland was 0.999; this coupling degree is high, which indicates that there is a strong correlation between migrants' willingness to transfer in to farmland and native farmers' willingness to transfer out of farmland and that they have a large degree of mutual influence and a close relationship.

The coupling degree of coordination was 0.68; thus, the willingness of migrants to transfer in to farmland and the willingness of native farmers to transfer out of farmland are seen to be in the basic coordination stage. At the present stage, the willingness of migrants to transfer in to farmland and the willingness of native farmers to transfer out of farmland can basically meet each other's needs. The reason for this difference may be that for most of the migrants, who are initially involved in agricultural production, relocation after the construction of their houses basically involves the use of land requisition compensation; at the same time, there are

TABLE 2 Factor detection results and weight.

Influencing factors	Transfer in	Weight	Influencing factor	Transfer out	Weight
I_1: Age	0.0511**	0.056	O_1: Age	0.033	—
I_2: Educational level	0.0546**	0.064	O_2: Educational level	0.057**	0.067
I_3: Level of nonfarm payrolls	0.0593***	0.076	O_3: Level of nonfarm payrolls	0.953***	0.051
I_4: Number of family agricultural laborers	0.221***	0.100	O_4: Number of family agricultural laborers	0.113***	0.181
I_5: Whether to participate in pension and medical insurance	0.015	—	O_5: Whether or not own a home in the town	0.031***	0.104
I_6: Land area before expropriation	0.045*	0.042	O_6: Farmland area per household	0.018	—
I_7: Distance to transferred farmland	0.322***	0.018	O_7: Degree of farmland fragmentation	0.676***	0.067
I_8: Value of farmland	0.265***	0.040	O_8: Farmland Transfer Organization	0.013	—
I_9: Farmland transfer organization	0.011	—	O_9: Whether there is unused land	0.926***	0.068
I_{10}: Financing opportunities	0.050***	0.146	O_{10}: Local nonfarm employment opportunities	0.886***	0.076
I_{11}: Local nonfarm employment opportunities	0.104***	0.111	O_{11}: Cognizance of the attribution of contractual rights after land transfer	0.391***	0.048
I_{12}: Availability of agricultural skills training	0.306***	0.244	O_{12}: Knowledge of land transfer policies	0.862***	0.072
I_{13}: Knowledge of land transfer policies	0.040*	0.038	O_{13}: Psychological perception of migrants	0.596***	0.071
I_{14}: Integration in settlements	0.467***	0.060	O_{14}: Expected returns from land transfers	0.817***	0.079
—	—	—	O_{15}: Degree of concern about damage to land rights and interests	0.933***	0.110

Note: ***, **, and * represent p-values of 0.01, 0.05, and 0.1, respectively.

TABLE 3 Results of the coupling coordination analysis.

Object	Value	Type
Index of willingness to transfer in	0.478	—
Index of willingness to transfer out	0.470	—
Coupling	0.999	High-level coupling
Degree of coupling coordination	0.68	Basic coordination phase
Relative degree of development	1.01	Development of the willingness of migrants and native farmers is to be simultaneous

fewer county and district secondary and tertiary industries, and there is less difficulty related to working. Compared with the self-farming behavior of the reservoir area, the self-sufficiency behavior of the area was found to be limited by the increase in the cost of living; additionally, as the land has been relocated to reduce the cost of living through the transfer of the willingness to be strengthened and through the resettlement area, more farmers have left to pursue work, thereby reducing the agricultural labor force. Similarly, as the agricultural labor force has become insufficient, part of the land has entered a state of abandonment. Additionally, there is also a certain willingness to flow out of the farmland, especially in the case of the nearby resettlement of migrants desiring to transfer in to farmland, which provides a certain market for the native farmers to flow out of the land.

The relative development degree of the two factors was found to be 1.01; thus, the willingness of migrants to transfer in to farmland is found to be essentially equal to the willingness of

native farmers to transfer out of farmland. The compensation for land acquisition is basically exhausted, and the subsidies for late-stage support have not yet begun to be subsidized. Thus, migrants, on one hand, urgently need to transfer in to farmland to reduce their cost of living, while on the other hand, they need to transfer into farmland to engage in agricultural production to make themselves stable. Furthermore, migrants need to create a sense of belonging and provide security for their long-term livelihoods, while on other hand, for farmers in the resettlement areas, their production and living styles have been fixed; they own part of the land because they do not want to let the land fall into disuse. At the same time, they obtain some land rents to subsidize their families; thus, the willingness of farmers in the resettlement areas to transfer out of farmland is not as strong as the willingness of the migrants to transfer to its disuse. In general, the willingness of migrants to transfer in to farmland in resettlement areas is basically consistent with the willingness of farmers to transfer out of such farmland.

Land in resettlement areas can be dynamically balanced between migrants and native farmers to achieve environmental and social sustainability.

5 Discussion

Reservoir migrants are predominantly impoverished rural residents with low levels of education (Scudder, 2005). In principle, the Chinese government takes "complete responsibility" for resettling displaced persons (Shi et al., 2012: 224). In capitalist countries, land can be treated as a commodity for purchase and sale, and the purchaser can possess ownership rights for the land. However, in China, land ownership belongs to state and collective economic organizations, and land cannot be bought or sold. Therefore, the Chinese government often exerts efforts to obtain land from other villages to resettle displaced migrants. This involves negotiations, land requisition, compensation, and other processes in villages, which require a considerable amount of time, effort, and compensatory payment. In the ongoing process of urbanization, profound changes occur in the production and lifestyle of farmers, both among different generations. The demands of migrants are also becoming increasingly diverse. The opinions of migrants should be respected (Wilmsen and Webber, Citation, 2015). Not all migrants are willing to accept land to continue agricultural production, and not all native farmers are willing to share land with migrants, even if they have received compensation. For large-scale water conservancy and hydropower projects, it is still viable to adopt a government-led land resettlement model (Wilmsen, B. 2018). When constructing large- or medium-sized water conservancy and hydropower projects, these costs and the voice of few migrants and native farmers seemed negligible. At present, the number of large-scale water conservancy and hydropower projects in China is gradually decreasing, and the number of small water conservancy and hydropower projects and the number of migrants generated by a single project are small. These costs and the related voices can greatly affect a small water conservancy and hydropower project. A more flexible method of resettlement is needed.

The example of the PQ Reservoir shows that the willingness of migrants and native farmers to transfer farmland basically matches. By transferring vacant rural land to migrants in need, we can more effectively utilize land resources and avoid wastage of resources. Takesada (2009) noted that resettlement programs require adequate attention to resettlers' voluntary choices and their far-sightedness when considering the next generation. A land transfer and resettlement model guided by the willingness of migrants can be established. Based on the needs of migrants and native farmers in the resettlement area, placement can be carried out through market-oriented land transfers managed under government supervision and regulation. This model can cater to the diverse resettlement needs of migrants by providing land for those willing to engage in cultivation while allowing those uninterested in agriculture to opt for employment, reducing damage to local ecology, thereby achieving environmental and social sustainability. Additionally, such a model helps avoid the complex tasks faced by the government during land

acquisition and reduces potential conflicts of ownership with native farmers.

This land transfer and resettlement model should be built on the foundation of fully respecting the wishes of both migrants and native farmers. Efforts should be made to maximize the willingness of migrants and native farmers to transfer land. It is crucial to ensure that the market-oriented transfer process is fair and transparent. Government supervision and regulation should encompass the oversight of the procedures and the pricing of land transfers to guarantee that the entire process is lawful and equitable. The tenure of land transfer should be extended as much as possible, because frequent land certification can lead to farmers excessively exploiting land resources in the short-term rather than sustainably using them (Tigistu, G,2011). Furthermore, the government should provide appropriate support and services to meet the basic needs of migrants in new resettlement areas, thereby facilitating their better integration into their new social environment.

6 Conclusion

The research primarily analyzed the influencing factors of land transfer willingness among migrants and native farmers in the PQ Reservoir and evaluated the coupled and coordinated relationships between them. The results showed that the ability to engage in agricultural production had an influence on the willingness of migrants, and the external policy environment had an influence on the willingness of native farmers, while land resource endowment and psycho–cognitive characteristics influenced both. The most concerning issue for native farmers during the land transfer process is the matter of land rights. The willingness of migrants to transfer in to farmland is strongly coupled with the willingness of native farmers to transfer out of farmland. There is a strong correlation between the two variables, and they significantly influence each other, indicating a close relationship. The willingness of migrants to transfer in to agricultural land matches the willingness of residents in resettlement areas to transfer out of agricultural land. This indicates the prioritization of agricultural land and a desire to ensure economic security by retaining land in the face of changes and potential risks. There is potential to establish a land transfer resettlement model based on the willingness for land transfer. This land transfer resettlement model is based on the willingness of migrants and native farmers and involves placing migrants on existing land to ensure their livelihoods, reduce the migrant cultivation of uncultivated land, and achieve the goal of improving land utilization efficiency and environmental and social sustainability.

In future land resettlement processes, the government can intervene in the external policy environment and in the context of psycho–cognitive characteristics to foster the willingness of migrants and native farmers, aiming to achieve a coupled and coordinated stage of mutual consent and then contribute to the environmental and social sustainability of resettlement areas. When implementing land resettlement, providing more financing opportunities is a crucial step. This can be achieved by establishing a dedicated land transfer fund or collaborating with financial institutions to offer loans and financial support to migrants

and native farmers. Such funds can be used for the purchase of agricultural equipment, seeds, and fertilizers, and also to support the development of rural enterprises, thereby promoting the increase in non-agricultural employment opportunities. Intensifying the promotion of land transfer policies is essential for enhancing public awareness and support. Through various channels such as media, social media, and promotional materials, conveying the significance and benefits of land transfer policies to native farmers, as well as explaining how to participate, can help establish community understanding and acceptance of land resettlement methods. To provide more non-agricultural employment opportunities, encouraging and supporting the development of rural enterprises is recommended. The government can promote the growth of rural enterprises by providing tax incentives, entrepreneurial support, and training. This, in turn, creates more job opportunities. Additionally, encouraging immigrants and native farmers to participate in the diversified development of rural industries helps cultivate new economic growth points. Community engagement is a crucial aspect of achieving integration between immigrants and native farmers. Facilitating understanding and communication between different groups by organizing various community activities, training courses, cultural exchanges, and establishing effective farmer cooperatives and agricultural organizations can promote resource sharing and collaboration, leading to mutual benefits in production and the daily life of migrants and native farmers. This approach can help minimize misunderstandings and conflicts that may arise during the land resettlement process. In this manner, land-for-land resettlement can proceed smoothly, thereby ensuring the migrants' livelihood restoration and resettlement environmental and social sustainability. Serje, 2015, Xu and Zheng, 2014

Data availability statement

The data analysed during the current study is not publicly available, as it relates to the privacy of migrants and farmers, and is only available from the corresponding author on reasonable request.

Author contributions

SC: funding acquisition and writing–review and editing. DY: methodology, software, writing–original draft, and writing–review and editing. ML: data curation, investigation, and writing–review and editing. JS: investigation and writing–review and editing. XW: investigation and writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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