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# Research on the livelihood capital and livelihood strategies of resettlement in China's South-to-North Water Diversion Middle Line Project

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Resettlement is an important part of water conservancy and hydropower projects, and its development is a proper means of comprehensively promoting rural revitalization. The issue of sustainable livelihoods in resettlement has always attracted significant attention. Based on the traditional sustainable livelihood framework, this paper attempts to incorporate psychological capital and construct a sustainable livelihood index system for resettlement caused by water conservancy and hydropower projects. It also adopts research data from 138 migrant resettlement sites along the middle route of the South to North Water Diversion Project, and employs generalized ordinal logistical models to carry out empirical research on the relationship between migrants' livelihood capital and livelihood strategies. The results show that the values of migrants' capital vary across different types of resettlement sites, and natural capital, physical capital, social capital, psychological capital are greatly affected by location distribution, while human capital and financial capital show only slight differences. The choice of migrants' livelihood strategies also varies across different resettlement sites, and these strategies are closely related to their livelihood capitals showing a positive correlation. The role played by different kinds of livelihood capitals in the transformation of migrants' livelihood strategies vary, and the impact of migrants' livelihood capital on this transformation also differs. The roles of various livelihood capitals in the transformation of migrants' livelihood strategies are different, and the extents to which each livelihood capital plays a role will change as migrants' livelihood strategies tend to diversify. This study can provide a reference for the formulation, implementation and optimization of policies related to the relocation and resettlement of migrants from water conservancy and hydropower projects, post-completion support and livelihood development.

## KEYWORDS

South-to-North water transfer, hydropower project resettlement, sustainable livelihoods, livelihood strategies, transformation

# 1 Introduction

Resettlement caused by water conservancy and hydropower projects, results in involuntary immigrants. This has become one of the most prominent problems in medium- and large-sized projects involving water conservancy and hydropower construction. This migration problem in China has always been the concern of Chinese scholars both home and abroad. China is not the only country facing the challenge of migrant resettlement since this is a global issue (Liu et al., 2018). People's livelihoods after resettlement is a key issue. The sustainable development of migrants' livelihoods directly affects the stability and prosperity of resettlement. This is related to promoting the revitalization of the countryside and realizing the benefits of high-quality development.

During May 2021, General Secretary Xi Jinping presided over a forum to promote the high-quality development of the follow-up project of the South-to-North Water Diversion in Henan Province. Before the meeting, General Secretary Xi Jinping investigated the construction and operation of the South-to-North Water Diversion Middle Line Project and the resettlement of immigrants. When inspecting the resettlement villages of this project, General Secretary Xi emphasized the need to continue to do a good job in the follow-up work of migrant resettlement and assistance and to ensure that the relocated people 65 and over can be stable, sustainable, and lucrative. Therefore, research on the livelihood of resettlement in water conservancy and hydropower projects is of great theoretical and practical significance for resettlement for sustainable economic and community development.

The research literature on sustainable livelihoods for resettlement in China and abroad is rich. Sustainable livelihoods research originated from Sen (1983) proposing solutions to poverty. In addition to examining the traditional meaning of income poverty, they also put special emphasis on the ability of poverty to compromise sustainable development. The more internationally recognized meaning of livelihoods is that they are ways of earning a living that is based on capabilities, assets, and activities (Chambers and Conway, 1992).

Academics have different understandings of what livelihoods encompass, different perspectives for analyzing sustainable livelihoods, and a variety of frameworks for analyzing sustainable livelihoods that have been proposed. Among these perspective is the Sustainable Livelihoods Approach (SLA) (DFID, 2000) proposed by the United Kingdom's Department for International Development (DFID) (Roberts and Guoan, 2003). Migrant relocation reduces the ability of re-settlers to have sustainable livelihoods (Kothari, 2009). Reasonable monetary and physical compensation should be provided (Koczberski and Curry, 2005). Compensation for resettlement should be able to maintain necessary living conditions, and reasonable compensation can increase the ability of resettlement to make sustainable livelihoods (Jackson and Sleight, 2000).

Mahdi and Schmidt-Vogt (2008) used the Sustainable Livelihood Framework (SLF) to measure the livelihood changes of households in West Sumatra in 1996 and 2006, evaluating the sustainability of environment, economy, society, and institutions. These researchers found that increased capital assets and improved economic status of poor households contributed to the overall increase in household economic sustainability. Oumer et al. (2011) validated the impact of livelihood capital on sustainable livelihoods of poor rural households, arguing that the government needs to raise the accessibility of key

assets for low-income farming households to help them out of poverty and that diversified livelihood strategies are beneficial to farm households in stabilizing their income, accumulating wealth, and mitigating risks (Nielsen et al., 2013). Amos et al. (2014) assessed the livelihoods of farming households in the coastal region of Nigeria and found that farm household livelihoods are very vulnerable and that farmers can only through the efforts of government or non-governmental organizations improve the sustainability of farm household livelihoods.

Wang et al. (2016) assessed the sustainability of farm household livelihoods by constructing an improved Livelihood Sustainability Index (LSI). This study found that the share of non-farm income of farm households is not always positively related to sustainability of livelihoods and that agricultural specialization may be an alternative pathway. These authors noted that low levels of education in rural areas will exacerbate the vulnerability of the poor and threaten the sustainability of the livelihoods of farming households. Jilito et al. (2018) argued that the choice of farming and non-farming strategies of farming households is influenced by the level of education, household size, remittances, farm inputs, irrigation, and distance from roads. Here, the choice of farms and non-farms is influenced by irrigation and non-farming training. The choice of farm and non-farm strategies is influenced by distance to markets which suggests that rural development should prioritize livelihood diversification.

Domestic research on the livelihoods of farming households began in 2004. Relevant studies have systematically analyzed the concept of livelihoods, analytical frameworks and approaches (Li et al., 2004). Research on the impact of relocation on the sustainable livelihoods of farm households has focused more on migrants relocated for poverty alleviation (Li and Gao, 2019; Liu and Li, 2019; Xu et al., 2019) and migrants from water conservancy and hydropower projects (Li et al., 2015, 2021; Zhao et al., 2019). Some progress has been made in sustainable livelihood studies for both types of migrants. They are mainly studies on the impact of relocation on the livelihoods of migrants and their livelihood vulnerability analysis, livelihood capital, livelihood strategies, and livelihood resilience.

The relocation of a large number of rural resettlements brought about by the construction of water conservancy and hydropower projects has resulted in significant changes in their livelihood capitals. As the sustainability of resettlement livelihoods is related to the resettlement and the long-term stability of society, the theory of sustainable Livelihoods has been widely applied to the study of the livelihoods of resettlement families in water conservancy and hydropower projects.

Zhao and Yang (2009) studied the vulnerability of migrants' livelihoods in the reservoir area of the South-to-North Water Diversion Project, and concluded that migrants in the reservoir area are affected by historical legacy problems and the external impacts of relocation, which make them vulnerable to livelihoods. They proposed that reliance on the migrant policy and strengthening migrants' awareness of their agency should be given equal importance, and that migrants should be supported to restore their livelihoods and rebuild their homes at the early stage, as well as to repair and reconstruct their capabilities at the later stage. Shangguan et al. (2019) summarized the factors influencing the livelihood vulnerability of reservoir migrants through the literature analysis method, classified the factors influencing the livelihood vulnerability of migrants in river diversion and Huaihuai River

using the ISM and MICMAC models, and objectively assessed the migrants' livelihood vulnerability. This provides reference support for improving the recovery efficiency of migrant livelihood vulnerability and scientific control of migrant livelihood vulnerability. Li et al. (2015) based on the sustainable livelihood analysis method, argued that migrants' livelihood capital, national cultural heritage, and the institutional policy environment affect migrants' livelihood strategies, and that migrants' vulnerability perception has a moderating effect on their livelihood strategies. These authors put forward countermeasures such as paying attention to disadvantaged groups and the disadvantaged livelihood capital of resettlement, and strengthening migrants' vocational education and medical insurance assistance.

Shi et al. (2011) took migrants in Danjiangkou Reservoir Area and the Three Gorges Reservoir Area as an example to explore the role of migrants' human capital in the process of their economic redevelopment. These authors argued that human capital has an important impact on the economic recovery of migrants, but compared with non-migrants, as well as the difference in the time of relocation, the phenomenon of human capital failure can occur. Cui et al. (2016) took the sustainable livelihoods of resettlement and aborigines in the Three Gorges Reservoir Area as an example, analyzed the differences between the two, and put forward research countermeasures to improve the livelihood situation of the residents and enhance the quality of life. Hu et al. (2018) took rural migrants in the Three Gorges Reservoir Area as the research object, analyzed the impact of different dimensions of livelihood capital and livelihood risk assessment on the level of sustainable livelihoods of rural resettlement, explored the path of sustainable livelihood development for rural resettlement with different types of livelihoods in the ethnic areas. These authors put forward that a differentiated model of livelihood capital cultivation based on livelihood risk assessment should be established.

Yan (2013) studied the connotation and characteristics of sustainable livelihoods of migrants, as well as the challenges and research outlook. They are specifically including the background of livelihood vulnerability, the measurement and comparison of livelihood capital, the development of the livelihood system, the change in livelihood structure, and the analysis of livelihood outcomes. Sun (2014) took migrants of Danjiangkou Reservoir of the South-to-North Water Diversion Middle Line Project as an example, focusing on livelihood issues such as migrants' livelihood capital, livelihood strategies, and livelihood outcomes. He combines the situation of early migrants and the characteristics of "second-generation" migrants, discusses the obstacles to migrants' non-agricultural transitions, and puts forward suggestions for the sustainability of migrants' livelihoods. Zhao and Zhang (2022) selected and constructed a livelihood indicator system and a livelihood stability index to analyze the livelihood capital, livelihood stability, and the degree of coupling between migrants and non-migrants, taking hydropower resettlement in the western region of Sichuan as an example. Sun and Li (2024) decomposed the sustainable livelihood capacity of resettlement into development capacity, economic capacity, and social capacity, and constructed six kinds of capital—namely, human capital, financial capital, physical capital, natural capital, social capital, and cultural capital. Based on this, the sustainable livelihood of migrants was evaluated, and the effect of post-assistance was assessed.

Existing studies have provided a richer perspective and laid a research foundation for conducting research on the sustainable livelihoods of water conservancy and hydropower project migrants. The inundation area of the reservoir of the South-to-North Water Diversion Project mainly involves Xichuan County, Nanyang City, Henan Province, and Danjiangkou City and Utopia District in Hubei Province, etc. More than 317,000 people have been relocated, and 482,000 acres of land have been inundated (including 256,000 acres of arable land), resulting in a 9.2% reduction in grain yield and a direct economic loss of 200 million yuan per year of grain. This has led to a deterioration of the cultivation environment and an increase in the cost of production in the vicinity of the reservoir. Therefore, research on the relationship between migrants' livelihood capital and livelihood strategies can help to improve migrants' livelihood capacities, ensure food security in the resettlement area, and is of great practical significance to promote migrants' prosperity.

This study takes the sustainable livelihood framework as a blueprint, and adds the psychological capital dimension to this basis, constructing a sustainable livelihood index system for migrants in water conservancy and hydropower projects. It uses the generalized ordered logistic regression model to carry out empirical research on the relationship between migrants' livelihood capital and livelihood strategies, revealing the contribution of migrants' livelihood capital variables to the transformation of livelihood strategies. The study aims to provide a reference for appropriately solving migrants' subsequent livelihood problems and for promoting the migrants to become prosperous and stable. It will provide a reference for properly solving migrants' subsequent livelihood problems and promoting their prosperity.

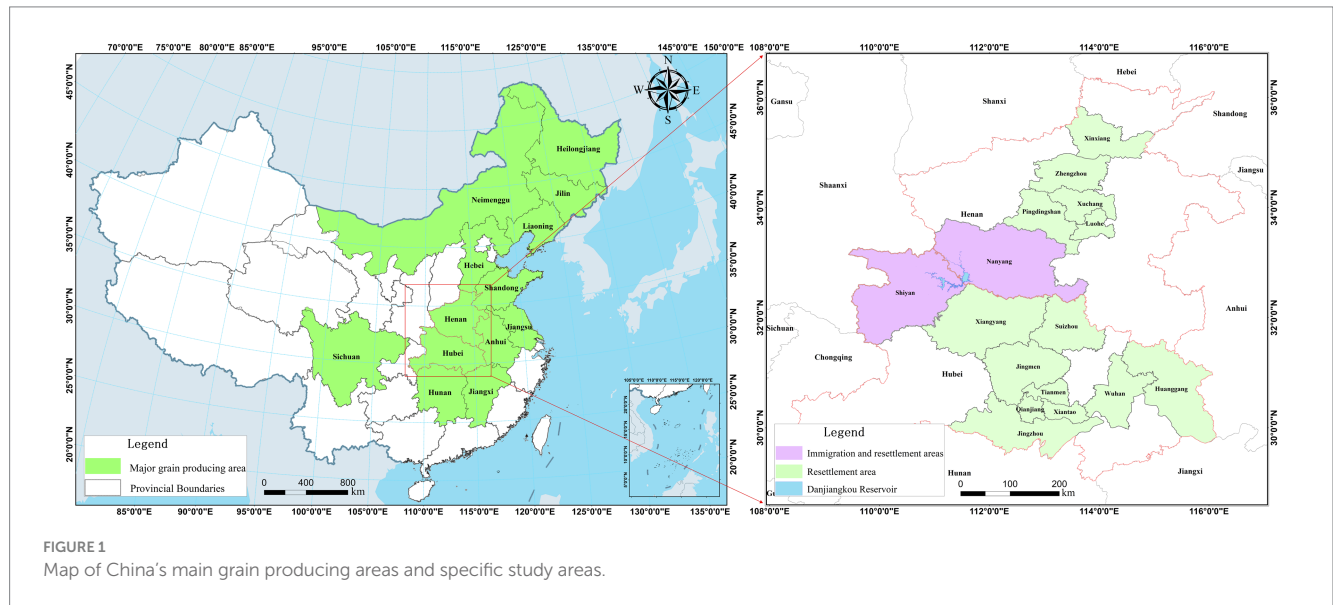
## 2 Materials and methods

### 2.1 Study area

The total trunk canal of the South-to-North Water Diversion Project is 1,277 km long, which draws water from the Danjiangkou Reservoir and transfers it through hardened nullahs to four provinces and cities, namely Henan, Hebei, Beijing and Tianjin. The first phase of the South-to-North Water Diversion Central Line Project can transfer an average of 9.5 billion m<sup>3</sup> of water per year, and the second phase is expected to reach an average of 13 billion m<sup>3</sup> per year. The first phase of the project was officially opened to the public in December 2014, and the cumulative water transfer from the Danjiangkou Reservoir up to May 2024 totaled 64.16 billion m<sup>3</sup>, with an annual power generation of 4.95 billion kW-h, benefiting a population of about 85 million people and bringing significant social, economic and ecological benefits. The results of the south-to-north water transfer are hard-won, the mainline project's relocation and resettlement, along with the reservoir's resettlement, involved nearly 420,000 people, including 345,000 Danjiangkou reservoir immigrants (Table 1). At the same time the project is providing huge benefits, the stability and prosperity of the immigrants should not be ignored. The South-to-North Water Diversion Central Line Project resettlement passed the overall acceptance in December 2019, marking the shift from relocation and resettlement to stable development of reservoir resettlement, and beginning a new journey in the post-Danjiang era. How to improve the sustainable livelihood of resettlement is a realistic

TABLE 1 Migrant relocation in the South-to-North Water Diversion Middle Line Project.

Category rural migrants	Henan Province			Hubei Province			Total
	Xichuan County	Danjiangkou City	Wudangshan Special Zone	Uyueyang District	Uyuexi County	Zhangwan District	
Residents	161,310	80,763	9,956	58,908	3,124	3,174	317,235
Other population	42	4,454		4,992	125	492	10,105
Total	2,404	8,375	301	6,191	187	100	17,558
Category	163,756	93,592	10,257	70,091	3,436	3,766	344,898



problem that needs to be addressed. Therefore, the study area of this paper is the migrant resettlement area of the South-to-North Water Diversion Central Line Project (see Figure 1 for details), involving more than 70,000 rural migrant households in 17 provincial (directly administered) municipalities in Henan and Hubei provinces, all of which are located in China's main grain-producing areas.

## 2.2 Data collection

The data of this study comes from the field research on the resettlement for the South-to-North Water Diversion Project conducted by the Research Group on Migrants' Stability and Development of North China University of Water Resources and Electric Power. This was done mainly obtained through questionnaires, semi-structured interviews, and field observations. The questionnaire covers three types of situations: resettlement households, migrant resettlement sites, and areas of migrant resettlement. Resettlement households focus on resettlement livelihood capital information such as resettlement family members, employment, housing, land resources, income and expenditure, and social integration. Migrant resettlement sites focus on demographic information of villages and groups, production materials, production projects, infrastructure, public facilities, and social stability. Resettlement areas focus on the topography, location and level of economic development of the

resettlement area. The project team is led by university teachers, mainly consisting of doctoral, master's degree, and undergraduate students from the water conservancy and hydropower institutions of high education. After preliminary training, field research was conducted in 138 migrant communities in 80 townships (townships and offices) in 30 counties (cities and districts) of 17 province-administered (directly administered) municipalities in Henan and Hubei provinces. A total of 1,197 households were surveyed, covering "hundreds of villages, thousands of households." The average household survey time was about 30 min, which ensured the quantity and quality of the samples. A total of 1,197 questionnaires were collected, and after screening and eliminating some incomplete questionnaires, 1,184 valid questionnaires were obtained from the resettlement respondents with the proportion of valid questionnaires reaching 98.9%.

## 2.3 Building a system of indicators for sustainable livelihoods

This study uses the Sustainable Livelihoods Framework (DFID, 2000) as an analytical framework to analyze livelihood changes and adaptations, mainly using the expert scoring method and literature review method to construct a sustainable livelihood indicator system for the resettlement of the South-to-North Water Diversion Middle



TABLE 2 Measurement indicator system of resettlement’s livelihood capital, method of assigning values.

Type of capital	Measurement indicators	Indicator measurement	Unit of measure
Human capital (HC)	Labor capacity (HC <sub>1</sub> )	Number of laborers	People
	Literacy (HC <sub>2</sub> )	Assignment of education level of family members	Dimensionless
Natural capital (NC)	Land area (NC <sub>1</sub> )	Land area <i>per capita</i>	Acre
	Land quality (NC <sub>2</sub> )	Land quality assessment	Dimensionless
Physical capital (MC)	Housing area (MC <sub>1</sub> )	Housing area <i>per capita</i>	Square meter
	Ownership of Durable Domestic Goods and Productive Assets (MC <sub>2</sub> )	Number of durable goods and productive assets owned	Piece
	Infrastructure evaluation (MC <sub>3</sub> )	Evaluation of the infrastructure situation	Dimensionless
Financial capital (FC)	Household income (FC <sub>1</sub> )	Household disposable income	Yuan
	<i>Per capita</i> income (FC <sub>2</sub> )	<i>Per capita</i> disposable income	Yuan
	Relief and subsidies (FC <sub>3</sub> )	Government assistance and policy subsidies received by households	Yuan
Social capital (SC)	Expenditures on favors (SC <sub>1</sub> )	Expenditure on family favors	Yuan
	Communications expenditure (SC <sub>2</sub> )	Expenditures on household communications	Yuan
	Scope of engagement (SC <sub>3</sub> )	Scope of the family’s social contacts	Dimensionless
Psychological capital (PC)	Life satisfaction (PC <sub>1</sub> )	Satisfaction with current life situation	Dimensionless
	Active Integration (PC <sub>2</sub> )	Degree of proactive integration into the settlement	Dimensionless
	Risk tolerance (PC <sub>3</sub> )	Attitude towards challenging and risky investments	Dimensionless

Line Project. First, based on the DFID sustainable livelihood analysis framework, 13 indicators are selected from five dimensions: human capital, natural capital, physical capital, financial capital, and social capital. Secondly, considering that psychological capital can effectively promote the effectiveness of other capitals of migrants, there are significant direct and indirect effects on livelihood status (Li, 2018). Psychological capital can also directly affect the social integration of migrant households and indirectly affect the social integration of migrant households through other factors (Zhang et al., 2015). This study adds the psychological capital dimension. Finally, a measurement system with 6 dimensions and 16 indicators was formed (Table 2).

Human capital is the capital that embodies the workers themselves, and directly determines the work capacity and skill level of migrant households, as well as the ability, scope and depth of utilization of other capital. The human capital indicators are selected from the migrant households’ labor capacity, literacy level (Cui and Wang, 2020). Natural capital is the stock of natural resources that are conducive to livelihoods, mainly referring to land resources that migrant households own or can use in the long term. The indicators of natural capital are selected as land area and land quality. Physical capital is a form of production material that exists over a long period of time, mainly referring to the infrastructure and material equipment needed by migrant households to maintain their livelihoods and production, etc. The indicators of physical capital are selected from the categories of housing area, ownership of durable goods for living and production, and evaluation of infrastructure (Zhou et al., 2020). Financial capital refers to the funds at the disposal of migrant households and the funds that can be mobilized through various channels. The financial capital indicators are selected from the income of migrant households, *per capita* income, and access to government assistance and policy subsidies (Yang and Zhao, 2009; Cai, 2010).

Social capital refers to all kinds of social resources owned by migrant families, which is the social network that can be utilized by migrant families to implement livelihood strategies. Social capital plays a very important role in the stable development of migrants affected by the South-to-North Water Diversion Project, and is an indispensable part of the sustainability of migrants’ livelihoods. Social capital selects the family’s favor expenditure, communication expenditure (Li et al., 2014), and the scope of interaction. Psychological capital refers to the psychological state of migrant families in the process of adaptation and development, and is a core psychological element that transcends human, financial and social capital, and is a psychological resource that promotes the adaptation of migrant families and increases their income and wealth. Psychological capital has the attributes of investment and profitability that are common to general capital, mainly including self-efficacy, hope, optimism, resilience, emotional intelligence and many other factors (Zhao et al., 2016). Psychological capital indicators are selected as life satisfaction, active integration and risk tolerance. The main factors include self-efficacy, hope, optimism, resilience, emotional intelligence, and many other factors (Zeng et al., 2018), and the psychological capital indicators are selected as life satisfaction, active integration, and risk tolerance (Su et al., 2016).

## 2.4 Dependent variable

Resettlement livelihood capital can be regarded as a comprehensive manifestation of the material wealth and spiritual capacity of resettlement families, and livelihood strategy is a concrete expression of resettlement families’ combined utilization of livelihood capital and use of different livelihood capital (Zhao and Zhao, 2021). Reasonable livelihood strategies are not only conducive to the realization of the potential energy of resettlement’s livelihood capitals,

but also help to improve the sustainability of resettlement's livelihood capitals and promote resettlement's families' sustainable income and wealth.

Drawing on the results of existing research (Chen and Fang, 1999; Ouyang et al., 2004; Zhang et al., 2008; Li, 2016; Ma et al., 2016, 2020; Walelign et al., 2016; Zhao et al., 2016; Chen et al., 2020; Shi et al., 2022) the classification of the type of farm household mostly examines whether the farm household is engaged in agricultural production activities and the proportion of non-agricultural income to the total income of the farm household. This study combines the field research in the migrant resettlement area of the South-to-North Water Diversion Project, and based on the different ways of livelihood of resettlement households (whether they are engaged in agricultural production activities or not) and the proportion of non-agricultural income in the migrant's total household income, the resettlement households' livelihood strategies are subdivided into the purely agricultural type, the agricultural-and-occupation type, the non-agricultural-and-occupation type, and the non-agricultural type, and are assigned the values of 1, 2, 3, and 4, respectively, in the model. The pure-farming type is for resettlement households that engage in agricultural production activities and have zero non-agricultural income. The part-time agricultural type is for resettlement households whose non-agricultural income accounts for less than 50% of the total household income. The part-time non-agricultural type is for resettlement households whose non-agricultural income accounts for more than or equal to 50% and less than or equal to 90% of the total household income. The non-farming type is for resettlement households whose non-agricultural income accounts for more than 90% of the total household income.

Based on the previous analysis, the dependent variables of this study are the livelihood strategies of the resettlement households, i.e., purely agrarian (AH), agricultural part-time (ABH), non-agrarian part-time (NABH) and non-farming (NAH).

## 2.5 Independent variable

Resettlement livelihood capital is key to the sustainability of resettlement household livelihoods. This study focuses on the relationship between migrants' livelihood capital and livelihood strategies in water conservancy and hydropower projects, taking resettlement households' livelihood capital as the core independent variable, i.e., human capital, natural capital, physical capital, financial capital, social capital, and psychological capital, and examining in depth the strength of the impact of each indicator. In addition, the location of migrant resettlement sites affects migrants' productive lifestyles to varying degrees and has varying strengths of impact on migrants' livelihood recovery and livelihood development (Chen et al., 2011; Xu et al., 2015). This study also considers the heterogeneity of the location distribution of migrant resettlement sites and categorizes them into purely rural (PR), suburbs of market towns (SMT), near industrial parks (PIP), and urban planning areas (CPA).

## 2.6 Combination weighting method

In order to more scientifically and effectively measure the importance of different indicators in migrants' livelihood capital, this

study adopts the subjective-objective combination weighting method to determine the weight of each indicator. This method combines subjective and objective weighting information, which can make full use of objective information and satisfy the subjective analysis of decision-makers as much as possible. The method is also characterized by clarity of thought, simplicity and practicality, and ease of software implementation (Xu and Da, 2002; Chen and Geng, 2013). Hierarchical analysis method and entropy value method are selected as the basis for setting indicator weights in the paper, and both of methods are given equal weights.

## 2.7 Analytic hierarchy process

Analytic hierarchy process (AHP) is a hierarchical weighting decision analysis method obtained by American operations researcher Prof. T.L. Saaty in the early 1970s by combining the network system theory and the comprehensive evaluation method of objectives, which has the advantages of being systematic, flexible, and concise (Li et al., 2017). Hierarchical analysis is a subjective assignment method, the calculation process is briefly described as follows (Deng et al., 2012).

The hierarchical analysis method is based on the principle of direct dominance degree to construct the judgment matrix. That is, the relative importance of indicators is estimated by comparing migrant livelihood capital indicators two by two under the same criterion, generally using the 1–9 scale method in which indicators are compared two by two and assigned a score. The judgment matrix for the criterion level is:

$$A = \{a_{ij} | i, j = 1, 2, \dots, n_b\}_{n_b \times n_b} \quad (1)$$

In the Equation (1),  $a_{ij}$  is the relative importance of the target layer as the judgment criterion, and is the relative importance of the criterion layer element  $i$  to the element  $j$ . In order to avoid such logical errors as  $a > b$ ,  $b > c$ , and  $c > a$  when the indicators are compared, a consistency test is needed after the sorting is completed.

After the above steps are completed, the eigenvalues and eigenvectors of the judgment matrix are found with the Equation (2):

$$\begin{cases} w_i^0 = \left( \prod_{j=1}^{n_b} a_{ij} \right)^{1/n_b} \\ w_i = \frac{w_i^0}{\sum_{i=1}^{n_b} w_i^0} \end{cases} \quad (2)$$

In the equation, is the value of the weights of the indicators of the sought resettlement livelihood capital.

## 2.8 Entropy weight method

The entropy method refers to the mathematical method used to determine the degree of dispersion of an indicator. Using the concept of entropy to measure the degree of influence of a certain evaluation indicator, the entropy value can be used to judge the degree of

discreteness (Fei et al., 2016) The entropy value method, an objective assignment method, determines the weight of each indicator based on the amount of information provided by its observation values, avoiding the subjectivity inherent in methods like the hierarchical analysis method and the Delphi method. The entropy method is used to determine the weights of various resettlement livelihood capital indicators, the higher the weight, the greater the impact of the indicator on the overall livelihood level of resettlement families. From Equations (3)–(8), the process of determining the weights of migrants' livelihood capital is briefly described as follows (Chen et al., 2009; Peng et al., 2016; Peng et al., 2018; Xu et al., 2019; Fei et al., 2022).

- (1) Standardization of data on indicators of resettlement livelihood capital.

$$P_{ij} = \frac{x_{ij} - \min\{x_j\}}{\max\{x_j\} - \min\{x_j\}} \tag{3}$$

- (2) Calculate the share of each indicator of resettlement livelihood capital.

$$f_{ij} = P_{ij} / \sum_{i=1}^n P_{ij} \tag{4}$$

- (3) Calculate the entropy value of each indicator of resettlement livelihood capital  $e_j$ .

$$e_j = -k \sum_{i=1}^n f_{ij} \ln f_{ij} \text{ included among these } k = 1 / \ln n \tag{5}$$

- (4) Calculate the information utility vale of the  $j$ th indicator  $r_j$ .

$$r_j = 1 - e_j \tag{6}$$

- (5) Calculate the indicator  $p_j$  of the weights.

$$w_j = \frac{r_j}{\sum_{j=1}^m r_j} \tag{7}$$

According to the entropy method, the weights of the indicators derived from the AHP model, and the standardized data, the value of each migrant's livelihood capital was obtained  $c_j$ . The value of each migrant's livelihood capital is obtained.

$$c_j = \sum_{i=1}^m w_j P_{ij} \tag{8}$$

The resettlement livelihood capital value can be calculated by adding the composite scores of the capital values of the indicators in each dimension. The value of resettlement livelihood capital ranges from 0 to 1 with a higher value indicating a higher level of resettlement livelihood capital.

## 2.9 Econometric model

The dependent variable of this study is the livelihood strategy of resettlement households. It is categorized into four ordered categories such as purely agricultural, agricultural part-time, non-agricultural part-time, and non-agricultural, and the survey data contains a variety of variable types, including continuous variables and dummy variables. For this reason, the paper considers using ordinal logistic regression modeling to explore the relationship between the livelihood capital and livelihood strategy of resettlement households.

There are usually three model forms of ordered logistic regression (Xing, 2015; Peng et al., 2016), the more commonly used is the Proportional Odds Model, but the model's premise requires the stricter parallel lines assumption (Parallel Line Assumption). In order to make the results more robust, this study adopts the Generalized Ordinal Logistic Model (GOLM), which relaxes the Parallel Line Assumption and takes into account the fact that the effect of the independent variables on the dependent variable varies with the change of the latent variable thresholds, which makes it more applicable (Tim, 2014; Huang et al., 2019).

$$\text{golgogit}(Y) = \alpha + \beta_1^* HC + \beta_2^* NC + \beta_3^* MC + \beta_4^* FC + \beta_5^* SC + \beta_6^* PC \tag{9}$$

In Equation (9), Y represents the type of livelihood strategy of the resettlement household, with the four strategies categorized as follows: purely agricultural (1), agricultural part-time (2), non-agricultural part-time (3), and non-agricultural (4), respectively  $\alpha$  and  $\beta$  are the model parameters to be estimated. HC, NC, MC, FC, SC, and PC represent the human capital, natural capital, physical capital, financial capital, social capital, and psychological capital of the resettlement households, respectively. The model was implemented by applying Stata17.0 software.

## 3 Results

### 3.1 Descriptive statistical analysis

#### 3.1.1 Basic characteristics of immigrant sample households

A total of 1,184 households with 5,585 resettlers is selected for the survey, with an average household size of 4.72 persons. There were 2,915 males in the sample, accounting for 52.2%, and 2,670 females, accounting for 47.8%. The average age of the head of household was 55 years old. The proportions of household heads with literacy levels were as follows: illiterate 6.7%, elementary school 29.8%, junior high school 48.7%, high school (or secondary technical school, etc.) 13.9%, and college and above 0.9%. The vast majority of the surveyed migrant households are agricultural specifically, 50.5% of the sample households are engaged in food production.

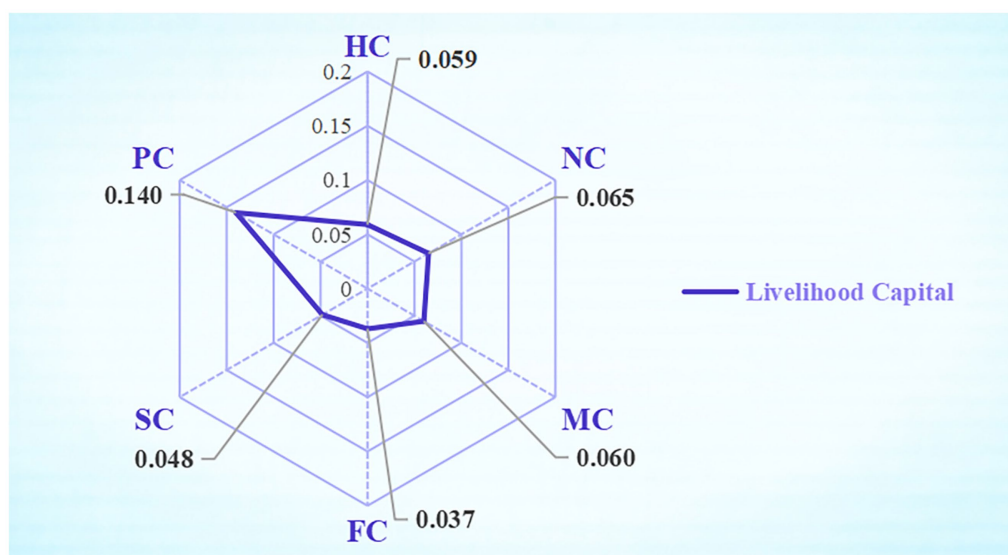


FIGURE 2

Capital value of resettlement livelihoods. The value of migrant livelihood capital ranges between 0 and 1. The higher the value of livelihood capital, the higher the level of migrant livelihood capital.

### 3.1.2 District distribution of resettlement sample villages

Regarding the location types of resettlement sites, there are 12 villages in urban planning areas, 28 villages on the outskirts of market towns, 8 villages close to industrial parks, and 73 purely rural villages. The proportion of each type of village in the sample villages is 9.92, 23.1, 6.6 and 60.3% respectively, which is basically consistent with the proportion of the location distribution of resettlement sites of the South-to-North Water Diversion Middle Line Project. Furthermore, according to the topography of the villages, there are 56, 26 and 39 plain, hilly and mountainous villages respectively, accounting for 46.3, 21.5 and 32.2% of the sample villages.

## 3.2 Quantitative analysis of resettlement livelihood capital

### 3.2.1 Comprehensive evaluation of resettlement livelihood capital

Based on the standardized measurements and weighting results, the capital value of migrants' livelihoods for the South-to-North Water Diversion Middle Line Project was calculated (Figure 2). In terms of ranking, the weights of the sub-capitals are, in descending order, financial capital, social capital, psychological capital, human capital, natural capital, and physical capital. While among the sub-capital values, psychological capital contributes the most, followed by natural capital, physical capital, human capital and social capital, with financial capital contributing the least.

The psychological capital value ranks first, which is a positive sign. Relocation has a great psychological impact on migrants, who not only have to face changes in their production and living environments, but also have the mental toughness to accept the loss of their original social environments and integrate into new ones. The migrants of the South-to-North Water Diversion Project belong to the whole-unit relocation and resettlement, and

the grassroots organizations are more sound and solid, and overall, the migrants have a high degree of life satisfaction and are gradually integrating into their new resettlement locations. Natural capital is ranked second, which indicates that the migrants of the South-to-North Water Diversion Project have been resettled in the way of large-scale agricultural production, and the land area and land quality are still very good. Physical capital is ranked third, which indicates that the migrants' housing conditions and infrastructure have been greatly improved, supporting the sustainability of migrants' livelihoods. After moving to their new houses, most of the migrants have purchased a lot of furniture and facilities, which has significantly improved their living standards.

The value of human capital is ranked fourth, which indicates a poor performance related to the migrants' low literacy levels and the absence of labor skills, as well as the low rate and poor quality of skills training, which will impact changes in human capital. The value of social capital is ranked fifth, indicating that migrant need to strength social interactions and the rebuilding social relations is a lengthy process, which is inseparable from Chinese farmers' "settling down and relocating," and the labeling of migrants' identities may also hinder their social integration. The value of financial capital ranks last, a stark contrast to its high importance in terms of financial capital, indicating that migrant have limited financial capital. Both migrant incomes and government assistance and policy subsidies are less than optimal, failing to capitalize on the critical role of financial capital in contributing to the sustainability of migrants' livelihoods.

### 3.2.2 Analysis of resettlement livelihood capital variables

According to the distribution of locations, the migrant resettlement sites of the South-to-North Water Diversion Central Line Project can be divided into pure rural areas, suburban areas of market towns, areas close to industrial parks, and urban planning areas. As can be seen from Table 3, in terms of human capital, there is no



TABLE 3 Analysis of resettlement livelihood capital variables.

Variables	PR		SMT		PIP		CPA		Norm weights
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
HC1	0.029	0.012	0.029	0.011	0.030	0.011	0.029	0.012	0.073
HC2	0.029	0.013	0.030	0.012	0.031	0.013	0.029	0.012	0.090
NC1	0.009	0.006	0.009	0.007	0.008	0.005	0.007	0.006	0.055
NC2	0.056	0.020	0.056	0.020	0.059	0.022	0.055	0.020	0.089
MC1	0.010	0.007	0.012	0.007	0.013	0.009	0.013	0.009	0.054
MC2	0.012	0.004	0.012	0.004	0.014	0.003	0.013	0.004	0.022
MC3	0.036	0.009	0.038	0.008	0.040	0.006	0.039	0.008	0.043
FC1	0.014	0.009	0.015	0.010	0.018	0.011	0.016	0.010	0.072
FC2	0.015	0.011	0.017	0.013	0.020	0.013	0.018	0.013	0.081
FC3	0.006	0.003	0.006	0.003	0.007	0.006	0.006	0.002	0.042
SC1	0.011	0.010	0.012	0.012	0.015	0.013	0.010	0.009	0.085
SC2	0.009	0.008	0.009	0.008	0.011	0.009	0.008	0.007	0.063
SC3	0.027	0.009	0.028	0.009	0.028	0.011	0.028	0.010	0.044
PC1	0.037	0.011	0.039	0.008	0.041	0.007	0.041	0.008	0.044
PC2	0.049	0.015	0.049	0.014	0.049	0.015	0.051	0.014	0.059
PC3	0.054	0.021	0.054	0.023	0.050	0.023	0.051	0.022	0.084

obvious difference in labor ability and literacy level among the four types of resettlement sites.

In terms of natural capital, the natural capital of different types of resettlement sites varies, with the more urbanized the location, the smaller the land area is. The land quality of resettlement sites close to industrial parks is better than that of purely rural areas and suburban areas, and the land quality of resettlement sites in urban planning zones is a little bit worse. Contrary to natural capital, in terms of physical capital, the more urbanized the resettlement sites tend to be, the higher their physical capital is, as evidenced by the fact that the area of housing and the ownership of durable goods and production assets near industrial parks and urban planning zones are higher than those in purely rural areas and the outskirts of towns and cities, and purely rural areas are rated lower in terms of infrastructure.

In terms of financial capital, there is little difference between the four types of resettlements sites, and household income and per capital income are lower in purely rural areas. In the aspect of social capital, the differences in human expenditure are larger, the human expenditure and communication expenditures in the urban planning area are lower, and the scope of interaction in the urban planning area is significantly larger, which is inseparable from the living habits of the residents in the urban planning area and the advantages of location and transportation.

In terms of psychological capital, the more urbanized the location of the resettlement site, the higher the degree of life satisfaction and active integration, which is highly related to the advantages of the surrounding locations and the degree of infrastructure improvement. Purely rural areas have a relatively higher risk tolerance, which may be due to the fact that the land brings the purely rural resettlement a stronger sense of psychological security.

### 3.2.3 Analysis of the distribution of resettlement households with different livelihood strategies in different resettlement zones

According to the criteria determined in this paper for classifying the livelihood strategies of resettlement households, the total sample consists of 60 households of purely agricultural type, 110 households of part-time agricultural type, 559 households of non-agricultural type, and 455 households of another non-agricultural type (Figure 3). They accounted for 5.06, 9.29, 47.21, and 38.43%, respectively. The non-agricultural part-time and non-agricultural types being the main livelihood strategies, and the purely agricultural type of livelihood strategy accounting for a very low percentage.

It can be seen that the choice of livelihood strategies varies across different types of resettlement sites, pure rural resettlement sites have the non-agricultural part-time type as the largest proportion accounted for 50.07%, followed by the non-agricultural type, accounting for 34.89%. The choice of livelihood strategies in market towns and suburban resettlement sites is similar to that in pure rural areas, with non-agricultural part-time and non-agricultural types leading, and the sum of the two accounting for a similar ratio. Near the industrial parks, the choice of livelihood strategies differs from the previous two, with non-agricultural part-time and non-agricultural strategies still dominant, but with non-agricultural in the lead. Urban planning area resettlement sites have non-agricultural livelihood strategies ranking in line with those of the industrial parks, both ranking first, but the combined ratio of non-agricultural, non-agricultural part-time livelihood strategies is poor, which indicates that non-agricultural employment in urban planning area resettlement sites has not reached the desired state. This indicates that the non-agricultural employment in the urban planning area has not reached the ideal state.

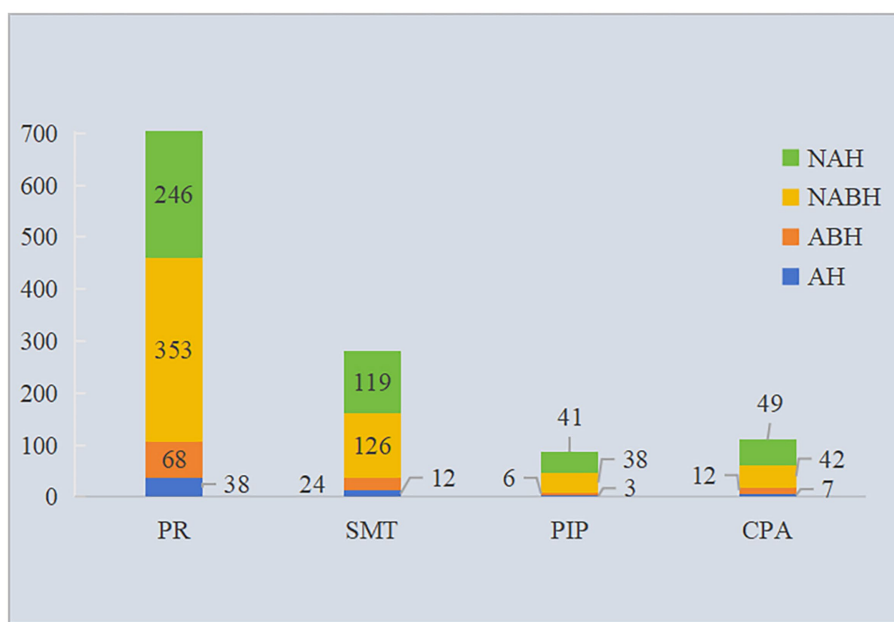


FIGURE 3 Distribution of migrant households with different livelihood strategies in different resettlement zones.

TABLE 4 Statistical results of resettlement’s livelihood capital and livelihood strategies.

Variables	Master sample		Purely rural		Suburbs of market towns		Proximity to industrial parks		City planning area	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HC	0.059	0.023	0.059	0.024	0.059	0.022	0.061	0.022	0.058	0.023
NC	0.065	0.021	0.064	0.021	0.065	0.022	0.067	0.022	0.063	0.022
PC	0.060	0.013	0.058	0.013	0.062	0.011	0.067	0.010	0.065	0.012
FC	0.037	0.021	0.035	0.020	0.039	0.022	0.045	0.023	0.040	0.022
SC	0.048	0.020	0.047	0.020	0.049	0.020	0.054	0.022	0.046	0.018
PC	0.140	0.027	0.139	0.027	0.143	0.028	0.141	0.030	0.143	0.025
LS	3.190	0.803	3.145	0.801	3.253	0.786	3.330	0.754	3.209	0.879

### 3.2.4 Statistical analysis of resettlement livelihood capital and livelihood strategies

As can be seen from Table 4, the sub-capital values of different types of migrant settlement sites also differ, especially the physical capital, financial capital, and social capital have large differences, while the human capital, natural capital and psychological capital have smaller differences and are not significantly different. This may be due to the fact that it takes a period of time for migrants’ intellectual labor, resource endowment, and mental toughness to change, so the differences are not significant, whereas migrants’ furniture and facilities, economic income, and social resources are more affected by the region where the migrant settlements are located.

In terms of livelihood strategies, the average score of livelihood strategies of the total sample is 3.190, which also indicates that the migrants’ livelihood strategy choices lean towards non-agricultural part-time and full-time non-agricultural activities. Based on the corresponding data from different types of migrant resettlement sites, it can be evident that the choice of migrants’ livelihood strategy is positively correlated with the value of livelihood capital and that the

migrants’ livelihood strategies are more inclined towards non-farming in the outskirts of market towns, close to industrial parks and in urban planning zones. Among these three types of resettlement sites, the highest value for the livelihood strategy is assigned to those near industrial parks, indicating that resettlement sites near industrial parks perform better in terms of non-farm employment, which further shows that resettlement of migrants should take into account not only the advantages of the location but also the availability of employment opportunities for the migrants.

### 3.3 Impact of livelihood capital on transformation of livelihood strategies

#### 3.3.1 Impact of resettlement livelihood capital on the transformation of livelihood strategies

Models (1–3) in Table 5 are the results of the ordered logistic regression of resettlement’s livelihood capital on the transformation of livelihood strategies. It can be seen that

TABLE 5 Results of ordered logistic regression of resettlement’s livelihood capital on livelihood strategy transformation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Livelihoodcapital	6.375***	6.386***	8.593***			
	(2.018)	(1.278)	(0.952)			
Humancapital				40.53***	41.29***	14.49***
				(7.379)	(4.977)	(3.297)
Naturecapital				-7.752	-12.42***	-15.51***
				(6.468)	(4.350)	(3.149)
Physicalcapital				-15.66	-29.16***	-1.783
				(10.76)	(7.748)	(5.480)
Financialcapital				0.838	7.085	24.16***
				(7.867)	(5.453)	(3.845)
Socialcapital				-7.871	-2.077	9.071**
				(8.724)	(5.809)	(3.715)
Psychologicalcapital				2.600	1.029	8.949***
				(5.298)	(3.503)	(2.486)
Constant	0.411	-0.755	-4.017***	2.422**	2.031***	-2.868***
	(0.783)	(0.503)	(0.401)	(1.005)	(0.689)	(0.489)
Log likelihood	-232.17953	-473.86315	-743.28926	-207.72175	-397.57743	-696.41191
Pseudo R <sup>2</sup>	0.0220	0.0272	0.0576	0.1250	0.1838	0.1170
LR chi <sup>2</sup> (1)/(6)	10.42	26.50	90.81	59.34	179.07	184.56
Prob > chi <sup>2</sup>	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	1,184	1,184	1,184	1,184	1,184	1,184

Standard errors in parentheses; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

livelihood strategies are sensitive to livelihood capital. Positive coefficients and larger values indicate a higher probability of resettlement choosing non-farm livelihood strategies, and vice versa.

The  $p = 0.0012 < 0.05$  of the LR statistic in model (1) indicates that model (1) fits better and is significant as a whole. Pseudo  $R^2 = 0.0220$  indicates that the independent variable in model (1) has a strong explanatory role for the dependent variable, and the corresponding parameters of the subsequent models are explained in the same way as in model (1) and will not be repeated. Therefore, the model results can be analyzed in more depth.

Table 5 shows that resettlement livelihood capital contributes significantly to the transformation of livelihood strategies at the 1% level. Among them, model (3) indicates that the coefficient of resettlement livelihood capital is the highest when transforming to non-farm livelihood strategies, that is, when other variables are held constant, the probability of choosing non-farm livelihood strategies increases by 8.593% for each unit increase in resettlement livelihood capital.

### 3.3.2 Specific effects of different resettlement livelihood capitals on the transformation of livelihood strategies

Models (4–6) in Table 5 show the results of the ordered logistic regression of different resettlement livelihood capitals on the transformation of livelihood strategies. It can be seen that human

capital, natural capital, physical capital, financial capital, social capital and psychological capital all affect the transformation of livelihood strategies to different degrees.

Model (4) shows that human capital plays a key role in the transformation of migrants’ livelihood strategies from purely agrarian to agricultural part-time, non-agrarian part-time, and non-agrarian and other three types of livelihood strategies, i.e., when other variables are kept constant, the probability of choosing a non-agrarian livelihood strategy increases by 40.53% for every unit increase in migrants’ human capital.

Model (5) illustrates that human capital continues to play a significant positive role in facilitating the transformation of migrants’ livelihood strategies from the first two to the last two, while natural capital and physical capital play an inverse inhibiting role.

Model (6) shows that financial capital, human capital, social capital, and psychological capital play significant facilitating roles, while natural capital continues to play a significant inhibiting role, and physical capital has no significant effect on the transformation of the first three livelihood strategies into non-farm livelihood strategies.

Unlike before, the positive role played by human capital has weakened, the negative impact of natural capital has continued to increase, and the influence of financial capital, social capital, and psychological capital has increased from weak to strong, with financial capital playing the most significant role in promoting the transformation.

TABLE 6 Results of ordered logistic regression of livelihood capital on livelihood strategy transformation in different types of migrant settlements.

Variables	Purely rural migrant settlements			Purely extra-rural migrant settlements		
	(7)	(8)	(9)	(10)	(11)	(12)
Humancapital	46.04*** (9.527)	44.60*** (6.378)	15.78*** (4.140)	31.75*** (12.16)	35.95*** (8.078)	14.67*** (5.640)
Naturecapital	-14.08* (8.355)	-19.19*** (5.737)	-21.22*** (4.248)	4.409 (10.63)	-2.502 (7.008)	-7.910 (4.837)
Physicalcapital	-25.27* (14.23)	-25.75*** (9.810)	1.092 (6.910)	0.521 (17.73)	-39.15*** (13.58)	-10.66 (10.02)
Financialcapital	-6.815 (9.508)	3.455 (7.076)	17.62*** (4.981)	16.01 (14.82)	12.03 (8.785)	34.59*** (6.501)
Socialcapital	-8.963 (10.75)	-5.376 (7.264)	2.070 (4.839)	-6.900 (14.97)	3.068 (9.587)	21.17*** (6.298)
Psychologicalcapital	1.340 (6.984)	2.158 (4.567)	9.811*** (3.258)	6.016 (8.636)	-1.244 (5.601)	6.258 (3.971)
Constant	3.638*** (1.246)	2.148** (0.838)	-2.412*** (0.613)	0.0315 (1.759)	2.313* (1.275)	-3.275*** (0.871)
Log likelihood	-122.36565	-237.39044	-412.1954	-81.126953	-156.78092	-271.91663
Pseudo R <sup>2</sup>	0.1729	0.2046	0.0960	0.0911	0.1676	0.1713
LR chi2 (6)	51.15	122.11	87.58	16.27	63.12	112.41
Prob > chi2	0.0000	0.0000	0.0000	0.0124	0.0000	0.0000
Observations	705	705	705	479	479	479

Standard errors in parentheses; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

### 3.3.3 Specific impact of migrants’ livelihood capital on the transformation of livelihood strategies in different types of settlements

In order to analyze the impact of livelihood capital on livelihood strategy transformation in different types of migrant resettlement sites in more detail, this paper will focus on the differences between purely rural migrant resettlement sites and the other types, which are categorized as purely rural and purely extra-rural. Models (7–9) and (10–12) in Table 6 are the results of the ordered logistic regression of migrants’ livelihood capital on livelihood strategy transformation in the two types of resettlement sites: purely rural and purely extra-rural, respectively.

Comparing models (7) and (10), human capital still plays a key role in the transformation of migrants’ livelihood strategies from purely agrarian to part-time agricultural, part-time non-agricultural, and other non-agricultural livelihood strategies, but the role of human capital in promoting the transformation of migrants’ livelihood strategies to non-agricultural is stronger in purely rural than in purely extra-rural areas, and in purely rural areas, natural capital and physical capital play an inhibitory effect, but this effect is not significant outside purely rural areas.

Comparing models (8) and (11), human capital still plays a key role in the transformation of migrants’ livelihood strategies from the first two types to the last two types. Natural capital plays a significant inhibitory role in purely rural areas but not significant outside purely rural areas. Physical capital plays an inverse inhibitory role in both types of settlements, with the inhibitory role being stronger outside purely rural areas.

Comparing model (9) and model (12), when migrants’ livelihood strategies shift from the first three types to the non-farm

type, financial capital plays a key facilitating role, which is more significant and stronger outside the purely rural areas. Human capital still plays a facilitating role, though the effect is weakened. Natural capital still plays a significant inhibitory role in purely rural areas but not significant outside pure rural areas. Social capital plays a more significant facilitating role in transforming the migrants’ livelihood strategies outside purely rural areas, which is more significant than in pure rural areas. Social capital has a more pronounced facilitating effect on the transformation of migrants’ livelihood in purely rural areas, but its significance is not recognized outside these areas. Psychological capital has a facilitating effect in purely rural areas, but its effect is not significant outside these areas. Physical capital’s effect is not significant.

## 4 Discussion

On the basis of the sustainable livelihood framework, this study attempts to add the dimension of psychological capital. It takes a multiple approach from the hardware security of migrants and the “soft power” of migrant families, which takes into account the traditional research paradigm and enriches the connotation of new livelihoods. It helps to analyze the livelihood issues of migrants in a more comprehensive and systematic way. At the same time, this study takes migrants of the South-to-North Water Diversion Project as the research object. The scope of the survey covers the entire reservoir area and migrant resettlement area, which is more comprehensive than previous small-scale surveys. Thus, the current situation of migrants’ livelihoods is studied more systematically and scientifically,



and the relationship between livelihood capital and livelihood strategies is analyzed in depth. It is of great theoretical and practical significance for improving the livelihood capacity of migrants, guaranteeing their food security and promoting their prosperity.

(1) Migrants' livelihood capital is significantly affected by relocation and resettlement, and it varies with the types of resettlement sites. The weights of the six types of capital for migrants in the South-to-North Water Diversion Project are financial capital>social capital>psychological capital>human capital>natural capital>material capital. And the capital values are psychological capital>natural capital>material capital>human capital>social capital>financial capital. This indicates that migrants' psychological capital, natural capital and physical capital perform better, human capital and social capital perform generally, and financial capital performs very poorly.

The immigrants of the South-to-North Water Diversion Project adopt the whole-unit relocation and resettlement method and the soil production resettlement method. Most of the new immigrant resettlement sites retain their original village names, and social relations within the villages remain relatively more intact. The immigrants' housing conditions are improved (before the relocation, the immigrant houses were mostly of earth and wood structure. After the relocation, all of them are of brick and concrete structure, and the *per capita* houses have increased to 34 square meters), and the infrastructure is more complete. This may be the reason for the better performance of migrants' psychological, natural and physical capital.

Human capital plays an important role in supporting the ability of migrants to make sustainable livelihoods. But at present, human capital has not fully played its due role and failed to effectively support the revitalization of migrant villages. Despite the relative integrity of social relations within the migrant villages, the relocation has led to a break in the migrants' external social relations, and it will take some time to rebuild the migrants' social relations as a whole. Relocation has had a great impact on migrants' income. Although the government has provided migrants with financial subsidies and project support through the late-stage support policy, there is still a long way to go for migrants to increase their income and become rich. Financial capital has not yet played a key role in supporting their ability to make a sustainable living.

(2) Migrants' livelihood strategy selection is significantly affected by livelihood capital, will change with different types of resettlement sites. The dominant livelihood strategies of migrants in the South-to-North Water Diversion Project are non-farming, accounting for more than 80% of the total. The resettlement sites are distributed in areas with sufficient jobs, and the migrants' livelihood strategies are more inclined towards non-farming. Migrants' livelihood strategies are sensitive to livelihood capital. The choice of livelihood strategies is positively correlated with the value of livelihood capital—the larger the value, the greater the probability of migrants choosing non-farm livelihood strategies.

The role of different migrants' livelihood capitals on the transformation of livelihood strategies is also different, and the extent of the role of sub-livelihood capitals in the transformation process to non-farm livelihood strategies is also changing. Human capital plays a crucial role in the transformation of migrants' livelihood strategies. But its role tends to diminish as the degree of non-farming increases. Natural capital and physical capital play an inverse inhibitory role in the transformation of migrants' livelihood strategies to non-farming. While financial capital, social capital, and psychological capital play a

significant role in promoting this transformation to non-farming livelihood strategies.

(3) Different types of resettlement sites have different impacts on migrants' livelihood capital and their livelihood strategy selection. Different types of resettlement sites also have different values of capital. Natural capital, physical capital, social capital, and psychological capital are strongly influenced by the location distribution of settlements. Human capital and financial capital show little difference.

The impact of migrants' livelihood capital on the transformation of livelihood strategies varies across different types of resettlement sites. Human capital still plays a key role, but its influence is stronger in the livelihood strategies of purely rural migrants. Natural capital and physical capital play an inhibitory role in the livelihood strategies of migrants, and this role changes at different stages of transformation across various resettlement sites. In the transformation of migrants' livelihood strategies to non-agricultural types, the role of financial capital is the strongest, while the role of human capital is diminished, and the impact of other capitals varies across different types of settlements.

Therefore, attention should be paid to the cultivation of migrants' human capital and the enhancement of their capacity for sustainable livelihoods. The resettlement of migrants can also try to break up the original village system, and consideration can be given to choosing resettlement sites that take into account the skills of the migrants and the location of the area. While guaranteeing food security, migrants should be actively guided to diversify their livelihood strategies in an effort to promote their stable and sustainable development.

## 5 Conclusion

This paper measures the livelihood capital of migrants in the South-to-North Water Diversion Central Route Project based on the sustainable livelihood framework. And the relationship between livelihood capital and livelihood strategy was studied using generalized ordered logistic regression model. The following conclusions can be drawn:

The value of the migrants' livelihood capital of the South-to-North Water Diversion Central Line Project is ranked as psychological capital>natural capital>physical capital>human capital>social capital>financial capital. The natural, physical, social, and psychological capital are greatly affected by location distribution, while human and financial capital show a slight difference.

The selection of livelihood strategies by migrants within the South-to-North Water Diversion Project is shaped by their livelihood capital, with which they share a robust positive correlation. Human capital exerts a notably profound influence evolution of these strategies while natural capital and physical capital have a significant inhibitory effect. Meanwhile, the other three forms of capital—namely social, psychological, and financial—contribute notably to the positive shift towards non-agricultural livelihood strategies. The choice of livelihood strategies by migrants in different types of resettlement sites varies. The more jobs there are around the resettlement sites, the more diversified the migrant's livelihood strategies tend to be. The influence of migrants' livelihood capital on the livelihood strategy transformation varies with different types of resettlement sites. The significant role of livelihood capital evolves through the different stages of livelihood strategy transformation. However, human capital playing a consistently critical role.

This study still has some limitations. There is a need to further optimize and improve the migrant sustainable livelihood indicator system to improve the precision of livelihood capital measurement. In future research, the use of continuous tracking and monitoring of sample data to realize dynamic analysis and application will be the direction of efforts.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

QL: Conceptualization, Formal analysis, Project administration, Supervision, Writing – original draft. YX: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. XZ: Data curation, Formal analysis, Methodology, Writing – original draft. JX: Investigation, Methodology, Software, Writing – review & editing. TJ: Investigation, Software, Writing – original draft. ZS: Conceptualization, Investigation, Supervision, Writing – review & editing.

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## 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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