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## REVIEWED BY

Dingde Xu,  
Sichuan Agricultural University, China  
Tianhe Jiang,  
Nanjing University of Posts and  
Telecommunications, China

## \*CORRESPONDENCE

Wei Liu  
lwei@xauat.edu.cn

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# Livelihood adaptive capacities and adaptation strategies of relocated households in rural China

Wei Liu<sup>1\*</sup>, Yuan Cheng<sup>2</sup>, Jie Li<sup>3</sup> and Marcus Feldman<sup>4</sup>

<sup>1</sup>School of Public Administration, Northwest Rural Revitalization Research Center, Xi'an University of Architecture and Technology, Xi'an, China, <sup>2</sup>School of Public Administration, Xi'an University of Architecture and Technology, Xi'an, China, <sup>3</sup>School of Public Administration, Xi'an Jiaotong University, Xi'an, China, <sup>4</sup>Department of Biology, Stanford University, Stanford, CA, United States

Adaptation to environmental change is the focus of sustainability research. Rural households face multiple environmental and social pressures due to global environmental change, so effective livelihood changes must be made to reduce capability losses and adapt to current or future livelihood challenges. Livelihood adaptive capacity and its evaluation provide a new framework for research into the livelihoods of relocated households, we attempt to evaluate the livelihood adaptive capacity of rural households in disaster resettlement areas and to explore how disaster resettlement affects the choice of adaptation strategies. Taking the case of southern Shaanxi as an example, this paper selects indicators from the dimensions of awareness, ability, and action. An index system is constructed for evaluation of farmers' livelihood adaptive capacity, and factors influencing the adaptation strategy are identified by using the multinomial probit regression model. The analysis shows: (1) the most adaptation strategies adopted after disaster resettlement are "expansion strategy," "expansion and adjustment strategy," "expansion and assistance strategy," and "expansion and adjustment and assistance strategy"; (2) disaster avoidance relocation has a significant impact on expansion strategies, and whether centralized resettlement has a significant effect on the choice of "expansion strategy" and "expansion and adjustment strategy"; and (3) household size, physical assets, and skills training also have a significant impact on the choice of adaptation strategies. Local governments should increase the assistance to the relocated households, improve the households' livelihood adaptive capacity, and encourage adoption of the most favorable adaptation strategies.

## KEYWORDS

disaster resettlement, relocated households, sustainable livelihood, adaptive capacity, adaptation strategies

## Introduction

Disaster generates enormous stress on people's living environments at multiple scale in time and space (Xu et al., 2022). Such as, long-term flash floods and prolonged droughts, pose a serious threat to the livelihoods and safety of tens of millions of people. In order to reduce ecological deterioration, to improve people's livelihoods and human wellbeing, and to promote social development, the Chinese government has undertaken the largest disaster resettlement program in history. This innovative initiative had been one of the keyways to address poverty in China (Zeng et al., 2015; Lo and Wang, 2018; Li et al., 2021b). Current research on disaster resettlement has focused on livelihood resilience (Liu et al., 2020a), livelihood capacity (Zhu and Yu, 2021), and livelihood diversification (Li and Sun, 2021). Households move from their fragile environments to relatively well-resourced areas, where their quality of life should be improved through further training and targeted government subsidies (Rogers et al., 2019). Disaster resettlement can change household's livelihoods as well as social structure (Chen et al., 2018; Yin et al., 2021), while it requires a systemic transition in our socioeconomic system to a more sustainable trajectory. In essence, a "just transition" aims to promote livelihood resilience and sustainable economic development, thus there is a pressing need to explore livelihood adaptation after disaster resettlement since resilience and adaptive capacity are tightly related in the perspective of system theory. Previous studies have found that disaster relocation showed significant negative effects on the resilience of farmers' livelihoods (Liu et al., 2020b), while this article attempts to illuminate the livelihood adaptation after disaster resettlement.

Previous research on adaptability has focused on the concept and how to measure it (Gunderson and Holling, 2002; Yin et al., 2021). For instance, Engle (2011) define adaptability as the process of using one's own reserve resources to dynamically adapt to and maintain the current state in the face of disturbance. Adaptive capacity is a measure of adaptability. Adger et al. (2005) argue that the concept of adaptive capacity is based on vulnerability and resilience, and that adaptive capacity plays an extremely important role when the external environment changes. There has been various studies within a framework of resilience and vulnerability, most of these works were in the context of climate change (Alam et al., 2016). For example, Yang et al. (2021) explored the relationship between livelihood resilience and adaptation strategies from the perspective of vulnerability. They found that livelihood resilience was positively correlated with farmers' choice of pure agricultural livelihood strategies. Chen et al. (2018) constructed an adaptive capacity assessment framework from three aspects: buffering capacity, learning ability and self-organization, and further explored the relationship between farmers' adaptive capacity, adaptation outcomes and adaptation strategies in arid areas. Several recent studies have used the

SLA (Sustainable Livelihood Approach) framework to analyze livelihood adaptive capacity in the case of water resources (Zhao et al., 2016), social ecosystems (Yin et al., 2020), and environmental stress in arid areas (Wu et al., 2019). In response to natural disasters and hydropower development, Kura and Sengvilaykham (2017) argue that government-initiated or spontaneous relocation by farmers has an important impact on livelihood adaptability. Furthermore, scholars have constructed a system of farmers' livelihood indicators to provide reference for the calculation of livelihood capital, while the SLA framework considers that livelihood capital including natural capital, human capital, physical capital, financial capital and social capital. At the household scale, research on livelihood adaptation in the face of environmental change remains limited (Abid et al., 2016; Khayyati and Aazami, 2016). Although these studies have related to livelihood adaptive capacity, few scholars have combined adaptive capacity with adaptation strategies in the resettlement case. Therefore, this article strives to explore the disaster resettlement and livelihood adaptive capacity/adaptation strategies from the household level.

Livelihood adaptation strategy refers to the choice and combination of activities that households choose to maintain their livelihoods (Xu et al., 2018). Households have developed adaptation strategies in the harsh natural ecological environment to improve their own livelihood adaptive capacity. Ellis (1998) argues that households respond to changes in the environment through various economic activities (agriculture-related or non-agricultural). Increasing the diversity of household agricultural income is an effective adaptation strategy. In many developing countries, households increase their sources of income and reduce livelihood risks by adopting a variety of livelihood activities (Jiao et al., 2017). Some research has linked livelihood adaptation strategy with livelihood capital, and due to differences in household livelihood capital and living environments the choice of livelihood adaptation strategy can vary (Wan et al., 2018). Scholars have also analyzed farmers' livelihood vulnerability and adaptation strategies through theoretical models (Yang et al., 2021). Some analysis of the choice of livelihood adaptation strategy involves households facing external disturbance related to rural tourism (Stone and Nyaupane, 2015) and rapid urbanization. Most studies on adaptive capacity and strategy have focused on key ecological areas, tourist development areas, and arid areas, but few have been carried out within a disaster resettlement framework.

In terms of theoretical and empirical evidence concerning livelihood adaptive capacity, the SLA framework is commonly used. However, due to different regional characteristics and levels of development, empirical analysis for specific sites may not be applicable to other sites (Pandey et al., 2011). This paper helps fill this gap. Based on the previous literature, this paper constructs a livelihood adaptive capacity assessment framework from the three aspects of awareness, ability, and action, and then uses multiple regression methods to explore the

factors affecting the choice of households' adaptation strategies. We draw on existing literature to address the following two issues. First, what is the level of livelihood adaptive capacity of rural households in the context of disaster resettlement? Second, what is the impact of disaster resettlement on farmers' choice of adaptation strategies? This article uses survey data on households obtained in Ankang prefecture of southern Shaanxi Province. We construct an index system for the livelihood adaptive capacity of households, and use survey data to evaluate the impact of disaster resettlement on the livelihood adaptation strategy choice of households.

## Materials and methods

### Study site

The study was undertaken in Ankang Prefecture, one of the three prefectures in Shaanxi conducting disaster resettlement (Li and Sun, 2021). Ankang is located in an extremely poor part of the QinBa mountains, with three million permanent residents, rural households are highly vulnerable to poverty, and most of the poor live in middle and high mountainous areas with limited natural conditions, fragile ecological environment and undeveloped infrastructure. In addition, the three districts and counties involved in this survey are all key counties in the national poverty alleviation and development work. Local governments are faced with the tasks of environmental protection and social development (Liu et al., 2018). Southern Shaanxi is located in the upper reaches of the Yangtze River (Xu et al., 2022). It is a dangerous area to live in, and disaster prevention and mitigation have been a priority for local governments. In order to mitigate natural disasters caused by environmental degradation, in 2011 the Chinese government launched a disaster resettlement program, involving 2.4 million people in 28 counties in Shaanxi Province. Various protection and development policies are being implemented in the region, and Ankang Prefecture is a representative area to explore how to improve livelihood adaptive capacity, reduce vulnerability and improve human wellbeing.

## Data and methods

### Data sources

The data in this paper are from an investigation of rural households' livelihoods in Ankang Prefecture in southern Shaanxi Province, China. For details on the survey, refer to Li et al. (2021a). The three counties selected for the survey in Shaanxi Province are Hanbin District, Ningshan County, and Ziyang County all of which are key counties for poverty alleviation and development at the national level. We used stratified sampling to select respondents who

were heads of households or their spouses aged 18–65. We also carried out semi-structured interviews with village-level managers. Eight-hundred questionnaires were distributed, and 657 responses were received (98.06%). In the process of collecting research data, the research group first conducts pre-survey and questionnaire test at the place where the research is to be carried out, then corrects and improves the content of the questionnaire. Our team organize training and implement data quality control, finally the teachers and students of the research group use face-to-face interview to complete the investigation. This study took 459 relocated households as a sample that is somewhat representative. The survey includes basic information about families, livelihood capitals, livelihood activities, as well as relocation and settlement status. Semi-structured interviews included: ① participation in non-agricultural business activities, ② future development strategies of farmers; ③ the impact of the poverty alleviation policy on households' livelihoods. The research group implemented strict quality control in both the investigation stage and the data integration stage.

### Analysis method

Entropy was used to standardize each index. This method can effectively eliminate the subjectivity of determining the weights. The specific calculation steps were the following:

- (1) With  $n$  study subjects and  $m$  study indicators, the original data matrix  $X$  is constructed as follows:

$$X = (X_{ij})_{m \times n} \quad \text{where } i = 1, 2, \dots, n; \quad j = 1, 2, \dots, m. \quad (1)$$

- (2) Standardization:

$$\text{Positive indicators: } Y_{ij} = \frac{X_{ij} - \min\{X_{1j}, \dots, X_{nj}\}}{\max\{X_{1j}, \dots, X_{nj}\} - \min\{X_{1j}, \dots, X_{nj}\}} \quad (2)$$

$$\text{Negative indicators: } Y_{ij} = \frac{\max\{X_{1j}, \dots, X_{nj}\} - X_{ij}}{\max\{X_{1j}, \dots, X_{nj}\} - \min\{X_{1j}, \dots, X_{nj}\}} \quad (3)$$

- (3) Determine the weight  $W$  of the index.

- ① From the standardized value  $P_{ij}$ , the specific gravity  $P_{ij}$  of the household  $i$  for indicator  $j$  is calculated:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}}, \quad i = 1, \dots, n; \quad j = 1, \dots, m \quad (4)$$

- ② Calculate the entropy of the term  $j$  index:

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}), \quad j = 1, \dots, m \quad (5)$$

- ③ Calculate the difference coefficient  $g_j$  of the indicator  $j$  index:

$$d_j = 1 - e_j, \quad j = 1, \dots, m \quad (6)$$

④ Calculate the weight  $W_j$  for indicator  $j$ :

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j}, j = 1, \dots, m \quad (7)$$

In order to explore how disaster resettlement characteristics affect the choice of households' adaptation strategies, the Probit method is more suitable. Because the adaptation strategies choice by households are diverse. In this method, the sum of the probabilities of selecting each option is one, and the explanatory variables only change with the individual, not with the plan. Therefore, a multinomial Probit model was used to analyze the effect of relocation features on the choice of adaptation strategy. Rural households respond to external disturbances by out-migration, running shops, changing traditional farming activities, such as greenhouse planting and breeding, while for some rural households, they rely on social assistance to survive, or seek help from relatives and friends. So, the adaptation strategies are divided into three types: "expansion strategy," "adjustment strategy" and "assistance strategy" (Zhao et al., 2020). Here, the four strategies most used by households as the dependent variables, which are: "expansion strategy," "expansion and adjustment strategy," "expansion and assistance strategy," "expansion and adjustment and assistance strategy," and the independent variables including relocation types, resettlement approaches, relocation time and other related variables. The relocation types were divided into five categories. There are resettlement for poverty reduction, ecological restoration, disaster avoidance, development project and other reasons. The resettlement approaches refer to centralized resettlement and non-centralized resettlement. The relocation time were divided into two stages (Xu et al., 2022). The Short-term relocation means relocated for less than 3 years and for 3~5 years; the long-term relocation refers to more than 5 years.

### Indicator construction

With respect to farmer livelihoods, we define adaptive capacity as a framework related to awareness, ability, and action, which is adapted from the framework of Acosta et al. (2013) and Li et al. (2017). The difference between the two frameworks is the scale, the former is at the regional scale, the latter is at the community scale. Within their framework, adaptive capacity is described in terms of experience, material resources, technology, infrastructure, flexibility, and economic resources. We use this framework here in the context of disaster resettlement.

Based on the adaptive capacity evaluation proposed by Acosta and relevant literature, fifteen indicators were selected from the three dimensions of awareness, ability, and action to construct a livelihood adaptive capacity index for relocated households (Table 1). Experience reflects how relocated households adapt in the face of deleterious environmental changes (Alam et al., 2016; Sina et al., 2019b). More experienced

households can make better judgments when the external environment changes (Xu et al., 2022). In this paper, experience is assessed through the education and work experience of the households (Li et al., 2017); households with more work experience are more aware of the changes and impacts of relocation, so they are expected to adopt diversification strategies to reduce risk. Infrastructure is assessed by the distance to main roads from the village and by products and tools. The more products and tools that households have, the higher their quality of life (Alam et al., 2016). Material resources reflects the economic status of a household, with cultivated land area, housing area (Quandt, 2018), and housing structure being used here (Li et al., 2017). Technology emphasizes the skill level and social relationships acquired by farmers (Li et al., 2017), and the ability to use social networks and resources to cope with changes in the external environment; this includes participation in skills training, being a relative of a village cadre, and the level of trust (Xu et al., 2022). Farmers who participate in skills training are better able to choose adaptation strategies that benefit them. Rich social network relationships make it easier for households to withstand external risk shocks. The degree of trust refers to the sum of the degree of trust in close friends, village cadres, and neighbors (Xu et al., 2022). Flexibility refers to the ability of households to survive and rebuild during external environmental threats (Li et al., 2017), and includes income diversity and household size. Economic resources include economic assistance (Sina et al., 2019b), housing value, and per capita net income.

## Results and analysis

### Descriptive statistics of the basic case of the sample

Of the 459 relocated households that were selected, 395 were relocated voluntarily while 64 were relocated involuntarily. Among these, 354 households were centralized, 43 were scattered, 52 were self-determined resettlement, and ten households were relocated for other reasons. According to the relocation time division, the relocation of households is divided into two stages. Short-term relocation means relocated for less than 3 years and for 3~5 years; 211 were less than 3 years and 103 were 3~5 years. Long-term relocation refers to more than 5 years, a total of 145 households. There is some controversy over the division of willingness to relocate.

Wilmsen and Mark (2015) define voluntary relocation as the government's full disclosure of all information related to resettlement: free, prior and informed consent is given to all households. Meanwhile, the household has the right to refuse to relocate. Involuntary relocation does not provide the option to reside, and it's a forced relocation. In this paper, voluntary relocation refers that one cannot live in the

TABLE 1 Indexes of relocated households' livelihood adaptive capacity.

Components	Determinants	Indicators	Weights	Definition	Mean	Standard deviation
Awareness	Experience	Years of education	0.012	Total number of years of education/household size (years)	5.837	2.570
		Previous work experiences	0.013	Number of adult family members who were once employed (number)	1.514	0.476
Ability	Infrastructure	Distance to the main highway	0.315	Distance from the house to the village-level main highway	0.426	3.541
		Products and tools	0.007	Total assets owned by the families (The range standardization of assets)	0.338	0.120
	Material resources	Cultivated land area	0.117	Cultivated land per capita (mu/person)	1.171	2.989
		Housing area	0.020	Total housing area ÷ household size	38.400	29.562
		Housing type	0.002	Structure type of the house (clay wood = 0.33; brick wood = 0.67; brick concrete = 1)	0.950	0.156
	Technology	Skill training	0.175	Household members participation in training (0, 1)	0.179	0.383
		Village cadre relative	0.197	Number of relatives who served as village cadres (number)	0.368	1.103
Level of trust		0.002	Strong distrust = 1, moderate distrust = 2, general trust = 3, moderate trust = 4, strong trust = 5	14.890	2.489	
Action	Flexibility	Diversity income	0.001	Diversity of household income sources and degree of balance of the various incomes	0.211	1.353
		Household size	0.012	Number in household family (number)	4.512	1.592
	Economic resources	Economic assistance	0.057	Number of households available to provide financial aid (number)	3.817	4.942
		House value	0.022	Estimated value of the house (below 100,000 RMB = 1; 100,000–200,000 RMB = 2; 210,000–300,000 RMB = 3; 300,000 RMB and above = 4)	2.441	1.334
		Per capita net income	0.048	Total family income ÷ household size	5,635.722	6,238.159

original place due to poverty reduction, ecological protection, natural disasters and other reasons. Involuntary relocation refers to move from original areas due to development-induced

projects and tourism development. The *t*-tests were conducted to compare the capital characteristics of relocated voluntarily and involuntarily households and to compare short-term and

TABLE 2 Rural households' capital characteristics for different resettlement types and time.

Variables	Voluntary relocation		Involuntary relocation		Short-term relocation		Long-term relocation		T <sub>1</sub> value	T <sub>2</sub> value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Skill training	0.149	0.357	0.359	0.484	0.185	0.388	0.166	0.373	4.135***	0.498
Cultivated land per capita	1.251	3.088	0.676	1.032	1.409	3.343	0.656	1.413	1.474*	2.605**
Per capita net income	6,051.121	7,354.389	5,320.878	7,337.718	5,938.588	6,168.303	5,972.450	9,436.405	0.737	-0.046
Year of educated	5.765	2.597	6.275	2.375	5.691	2.531	6.152	2.635	-1.473	-1.792
Distance to the main highway	0.443	3.684	0.320	2.450	0.611	4.268	0.024	0.189	0.257	1.655***
Housing area	37.245	28.279	45.534	35.941	35.925	21.358	43.762	41.781	-2.089**	2.658***
Housing type	2.884	0.423	2.609	0.726	2.901	0.399	2.724	0.618	4.268***	3.682***
Products and tools	0.331	0.117	0.382	0.133	0.331	0.123	0.354	0.112	-3.211*	-1.918
Housing value	2.742	0.952	2.734	1.130	2.723	0.927	2.779	1.083	0.056**	-0.574**
Economic assistance	3.850	5.103	2.92	3.452	3.910	4.893	3.300	4.950	1.400	1.232
Village cadre relative	0.367	1.115	0.343	0.995	0.354	1.110	0.386	1.075	0.158	-0.296
Household size	4.483	1.559	4.687	1.781	4.519	1.546	4.497	1.692	-0.951	0.141
Work experience	4.400	1.255	4.203	1.482	4.363	1.272	4.393	1.330	1.134**	-0.232
Diversity income	0.228	0.722	0.104	2.531	0.275	0.286	0.072	2.007	0.796**	1.752*
Level of trust	14.754	2.612	14.843	3.648	14.685	2.689	14.944	2.955	-0.239**	-0.933
N	395	64	314	145						

T<sub>1</sub> Value refers to comparing the difference between voluntary relocation and involuntary relocation.

T<sub>2</sub> Value refers to comparing the difference between short-term relocation and long-term relocation.

\*, \*\*, and \*\*\* denote differences that are significant at  $p < 0.1$ ,  $p < 0.05$ , and  $p < 0.01$  levels, respectively.

long-term households. Comparing the average living capital of households of different relocation types, we see that skills training, per capita cultivated land, housing structure, housing value, housing area, work experience, income diversity, and level of trust differ significantly. The products and tools of relocated involuntarily households are more abundant, but the house values of relocated voluntarily households are higher. Comparing the average livelihood capital of households with different relocation time, the distance to the village main highway, housing area, housing structure, housing value, per capita cultivated land, and income diversity were all significantly different. With longer relocation time, households tend to diversify in their livelihoods and have significant advantages in material resources. Thus, disaster resettlement has improved these households' economic situation. The above results are shown in Table 2.

## Livelihood adaptive capacity and resettlement characteristic

The livelihood adaptive capacity index is calculated using entropy, and the results are as follows. There are clear differences between the livelihood adaptive capacity indexes of different relocation types (Figure 1). In general, the livelihood adaptive index of households is concentrated between 0.1 and 0.2, which is relatively low. The median of the livelihood adaptive capacity index of poverty reduction households is skewed to the lower quartile, and the overall performance is low and balanced. Although the livelihood adaptive capacity index of ecological restoration relocation households is relatively low, the overall performance is normal distribution. Compared with the other three types of households, the livelihood adaptive capacity index of disaster avoidance households and other relocation households is non-uniform distribution, showing a skewed distribution.

For the livelihood adaptive capacity with different relocation time, the cut-off point between the upper and lower levels of the livelihood adaptive capacity index above 5 years is different from the distance between the upper and lower quartile, and shows a relatively skewed distribution. The median of the adaptive capacity index of households' livelihood below 3 years and 3~5 years is positioned at the central of the box, and the higher cut-off point is far from the upper quartile, indicating that the index distribution is non-uniform (Figure 2). There are also differences in the livelihood adaptive capacity index of households with different relocation approaches (Figure 3). The median for the self-determined households is significantly higher than that of the other three relocation approaches. Therefore, the adaptive capacity index of households adopting this relocation approach is relatively high. This is due to the constraints imposed by the geographical conditions in the area;

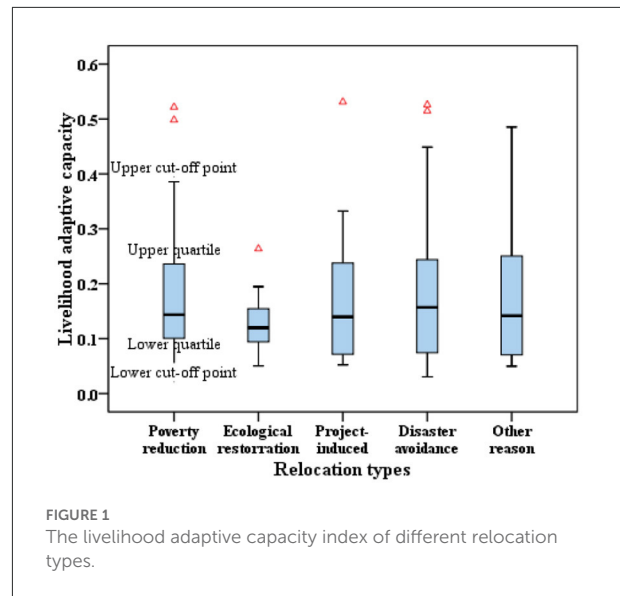


FIGURE 1  
The livelihood adaptive capacity index of different relocation types.

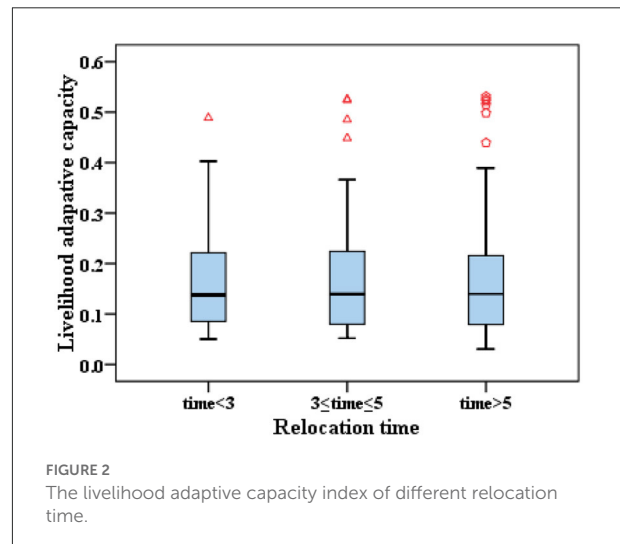
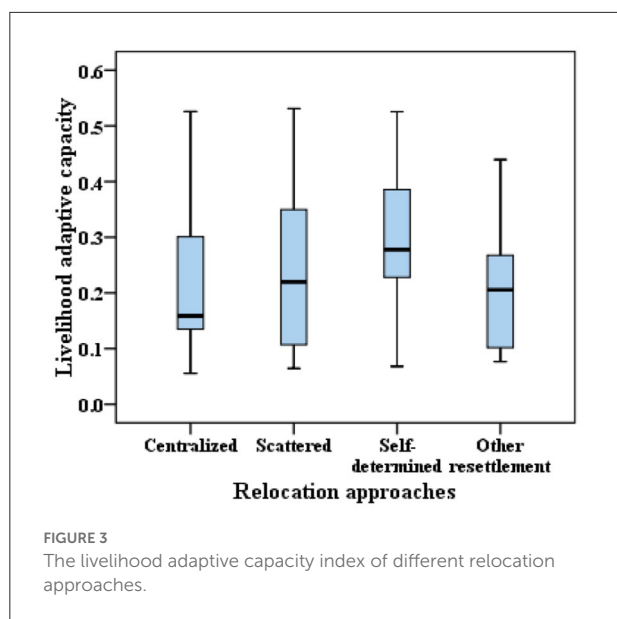


FIGURE 2  
The livelihood adaptive capacity index of different relocation time.

the local government cannot build a centralized resettlement community, and households mostly choose scattered relocation or self-determined relocation. These farmers have relatively high requirements for infrastructure and material conditions in the living environment, and they choose more adaptation strategies to meet the requirements, with the result that their livelihood adaptive capacity is generally high.

## Livelihood adaptation strategy of relocated households

Households face different levels of livelihood challenges in the process of relocation, and how they choose adaptation strategies is the key to maintaining sustainable livelihoods. To



analyze the adaptation strategies of households facing various livelihood challenges, we divide livelihood adaptation strategies of farmers in key ecological functional areas that face multiple pressures (Zhao et al., 2020) into three types. The first is the expansion strategy, which refers to increasing income sources by going out to work, operating small shops, transportation industry, accommodation, catering, automobile and agricultural machinery repair services. The second is the adjustment strategy, refers to engaging in breeding, greenhouse planting, and so on; the third is the assistance strategy, which refers to relying on external help to cope with livelihood challenges, such as borrowing money from friends, borrowing from banks, and receiving government poverty alleviation relief (Li et al., 2018). Among the relocated households, 94.99% adopted various adaptation strategies to maintain their own livelihood, and 64.71% adopted various (two or more) adaptation strategies to cope with the livelihood challenges.

Entropy was used to calculate the scores for the different adaptation strategies, and the results are shown in Figure 4. In terms of experience, the livelihood adaptive capacity scores of households with different types of adaptation strategies from larger to smaller are “expansion and adjustment and assistance,” “expansion and assistance,” and “expansion and adjustment”. The more experienced households tend to choose many different types of livelihoods. In terms of economic resources, the livelihood adaptive capacity score value of households varies greatly. The expansion farmers are obviously higher than the other three types, which shows that such households have a strong adaptive capacity to cope with external environmental changes. At the same time, relocation and resettlement leads to material resources of all types of households being at a low level because most of the households have lost their original cultivated land. In terms of technical capacity, the highest adaptive capacity

score is for the “expansion and adjustment and assistance” households, indicating that the higher their technical capacity, the wider their social network relationships, so that households have more choices to maintain their livelihood. In terms of infrastructure, the livelihood adaptive capacity scores of all types of households are low, indicating that the quality of life of the relocated households is generally low and they have few productive assets.

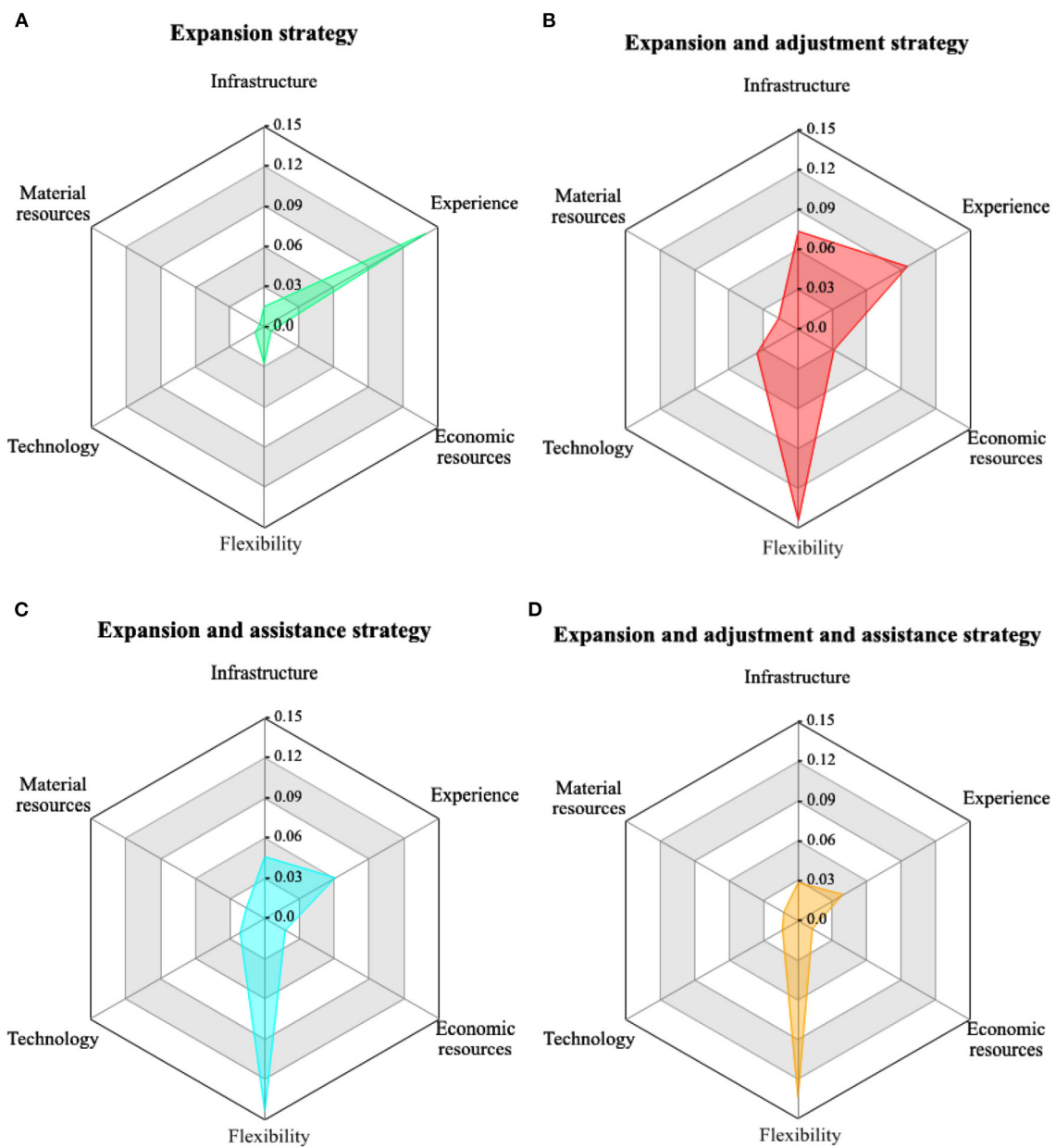
## The effects on the choice of adaptation strategy

In order to identify factors influencing households’ adaptation strategy type, we use a multinomial probit model and take each of the four adaptation strategies (“expansion strategy,” “expansion and adjustment strategy,” “expansion and assistance strategy,” “expansion and adjustment and assistance strategy”) as a dependent variable, and “expansion and adjustment and assistance strategy” as the reference group. Based on previous literature and our descriptive statistics, we take the relocation types, resettlement approaches, and relocation time of households as core independent variables. Household size, skills training, products and tools, per capita net income, per capita cash income, and the impact of government poverty alleviation policies on families are all control variables. The regression results are shown in Tables 3–5.

Compared with households who chose the “expansion and adjustment and assistance” strategy, some relocation characteristics have a significant influence on the choice of adaptation strategies. Disaster avoidance relocation has a significant positive impact on the choice of expansion strategy. This may be due to those households with disaster avoidance relocation receiving a certain amount of subsidies and having higher financial capability, so they are more likely to adopt expansion strategies, such as operating stores. The relocation time between 3 and 5 years and centralized resettlement have significant positive effects on the choice of expansion strategy. The longer the relocation time, the more that households adapt to local customs, and their environment improves, so they are more inclined to choose the expansion strategy. The centralized resettlement approach has a significant positive impact on the choice of expansion strategy of households, and although the coefficient is small, it is enough to show that the centralized resettlement approach can mitigate the external impact of relocation and settlement under reasonable planning and support from the government.

Compared with households who choose the “expansion and adjustment and assistance” strategy, among the relocation characteristics, relocation type and relocation time have a significant effect on the choice of adaptive capacity. Ecological restoration relocation has a significant negative effect on





**FIGURE 4** (A) Livelihood adaptive capacity score value of expansion strategy households; (B) Livelihood adaptive capacity score value of expansion and adjustment strategy households; (C) Livelihood adaptive capacity score value of expansion and assistance strategy households; (D) Livelihood adaptive capacity score value of expansion and adjustment and assistance strategy households.

the choice of “expansion and adjustment” strategy, which is due to the relocation being caused by the environment or natural disasters. Compared with project-induced relocation, ecological restoration relocation households have low risk-resistance capacity and are passively waiting for assistance. Long-term relocation households have a high adaptive capacity and diversify their adaptation strategies. In addition, skills

training and households’ understanding of policies are key factors influencing the choice of “expansion and adjustment” strategy. The more that households understand the policy, the more likely they are to choose the “expansion and adjustment” strategy. Households are more concerned about land policies and homestead land after relocation and settlement. The survey showed that after settling into a new settlement, many

TABLE 3 The impact of relocation types on the choice of adaptation strategy.

Variables	Expansion strategy			Expansion and adjustment strategy			Expansion and assistance strategy		
	Coef.	SE	Wald	Coef.	SE	Wald	Coef.	SE	Wald
Relocation types									
Poverty reduction	0.637	0.526	1.464	-0.841*	0.461	3.312	0.261	0.460	0.325
Ecological restoration	0.503	0.601	0.706	-1.635**	0.628	6.760	0.018**	0.543	0.130
Disaster avoidance	1.235**	0.511	5.856	-0.361	0.441	0.672	1.015	0.446	0.001
Other reason	0.436	0.551	0.624	-0.642	0.483	1.769	0.034**	0.482	5.198
Household size	-0.343***	0.095	12.960	-0.343***	0.091	1.096	0.320***	0.083	14.746
Skill training	-0.974**	0.316	9.486	-1.046**	0.339	9.486	-0.405	0.281	2.074
Products and tools	0.193**	0.076	6.452	0.010	0.081	1.513	0.096	0.074	1.690
Per capita net income	-1.077**	0.340	10.049	-0.397	0.283	1.960	-0.879***	0.252	12.180
Cash income	0.754**	0.293	6.605	0.310	0.228	1.849	0.618**	0.200	9.548
Impact of government poverty alleviation policies	1.037**	0.344	9.060	0.708**	0.325	4.752	0.155	0.240	0.410
Constant	-0.811	1.488	0.323	-0.688	1.494	0.212	2.247	1.204	3.497
Log likelihood									-469.24
Pseudo R <sup>2</sup>									0.0000
N									394

“Relocation type” takes project-induced resettlement households as the reference group.

\*, \*\*, and \*\*\* denote differences that are significant at  $p < 0.1$ ,  $p < 0.05$ , and  $p < 0.01$  levels, respectively.

TABLE 4 The impact of resettlement approaches on the choice of adaptation strategy.

Variables	Expansion strategy			Expansion and adjustment strategy			Expansion and assistance strategy		
	Coef.	SE	Wald	Coef.	SE	Wald	Coef.	SE	Wald
Whether centralized resettlement	0.609**	0.282	4.666	-0.098	0.282	0.123	0.524*	0.257	4.162
Household size	-0.338***	0.093	13.104	-0.154*	0.089	2.993	-0.313***	0.081	14.746
Skill training	-0.983**	0.311	9.425	-0.983**	0.334	8.644	-0.415	0.273	2.310
Products and tools	0.203**	0.077	6.917	0.111	0.081	1.904	0.111	0.074	2.220
Per capita net income	-0.997**	0.329	9.181	-0.368	0.275	1.796	-0.804**	0.242	11.089
Cash income	0.716**	0.284	6.350	0.283	0.224	1.588	0.583**	0.192	9.181
Impact of government poverty alleviation policies	0.947**	0.336	7.896	0.778**	0.335	5.382	0.104	0.239	0.185
Constant	-0.583	1.370	0.185	-1.433	1.449	0.980	2.107	1.137	3.423
Log likelihood									-481.33
Pseudo R <sup>2</sup>									0.0000
N									394

\*, \*\*, and \*\*\* denote differences that are significant at  $p < 0.1$ ,  $p < 0.05$ , and  $p < 0.01$  levels, respectively.

households no longer rely on agriculture to make a living, but choose the expansion and adjustment strategy, with part-time work and employment of agricultural technique, to maintain their livelihoods.

Compared with households who choose the “expansion and adjustment and assistance” strategy, among the relocation characteristic variables, ecological restoration relocation has a significant effect on the choice of “expansion and assistance” strategy. A possible explanation is that households who relocate

due to natural disasters are in a state of passive rescue for a short period of time. The relocation time of 3–5 years has a significant positive impact on households’ choice of the “expansion and assistance” strategy, which may be because the government’s policy on relocated households has a better effect in the short term. Centralized resettlement also has a significant positive impact, indicating that households who choose centralized resettlement enjoy high government subsidies and are more inclined to choose the “expansion and assistance” strategy.

TABLE 5 The impact of relocation time on the choice of adaptation strategy.

Variables	Expansion strategy			Expansion and adjustment strategy			Expansion and assistance strategy		
	Coef.	SE	Wald	Coef.	SE	Wald	Coef.	SE	Wald
Relocation time									
3 ≤ Time ≤ 5	0.549*	0.308	3.168	0.547	0.341	2.56	0.842**	0.289	8.526
Time > 5	0.255	0.284	0.81	0.805**	0.295	7.453	0.016	0.275	0.003
Household size	−0.347***	0.094	13.616	−0.175*	0.091	3.725	−0.338***	0.083	16.565
Skill training	−1.118**	0.303	13.616	−0.956**	0.327	8.526	−0.566**	0.268	4.452
Products and tools	0.167**	0.076	4.884	0.067	0.082	0.672	0.078	0.074	1.124
Per capita net income	−1.004**	0.335	9.000	−0.360	0.278	1.69	−0.808***	0.247	10.628
Cash income	0.722**	0.289	6.250	0.295	0.224	1.716	0.586**	0.198	8.762
Impact of government poverty alleviation policies	0.960**	0.327	8.644	0.808**	0.335	5.808	0.155	0.241	0.410
Constant	−0.124	1.329	0.008	−1.878	1.461	1.664	2.425*	1.139	4.537
Log likelihood						−474.95			
Pseudo R <sup>2</sup>						0.00			
N						394			

“Relocation time” takes Time < 3 as the reference group.

\*, \*\*, and \*\*\* denote differences that are significant at  $p < 0.1$ ,  $p < 0.05$ , and  $p < 0.01$  levels, respectively.

## Discussion

Disaster resettlement is an important way to reduce poverty and the effects of natural disasters, and it is a method for developing the livelihoods of local households. To achieve a “just” and systemic transition, this innovative initiative seeks to diminish livelihood vulnerability, to improve and enhance livelihood resilience and adaptation. In this article, the results show that the livelihood adaptive capacity of households with different resettlement approaches varies. Previous studies have found that short-term resettlement reduces the livelihood adaptive capacity of relocated households (Rogers et al., 2019; Xu et al., 2022). There are also clear differences in the livelihood adaptive capacities of households with different adaptation strategies, the most significant of which is that households that choose the “expansion and adjustment and assistance” strategy have the highest technical ability and relatively low economic resource capacity. This shows that compared with economic resources, the reshaping of social networks is a bigger problem for relocated households. Strong social networks and a high level of social capital can significantly reduce the vulnerability of households, and strengthen their livelihood capital (Quandt et al., 2017; Quandt, 2018). Overall, having a strong social network is good for relocated households by promoting livelihood recovery and achieving diversified livelihoods (Sina et al., 2019a,b). As for adaptation strategy, Yang et al. (2021) found that the non-farming livelihood strategy is the main livelihood strategy for farmers in different disaster-type-threatened areas.

Meanwhile, the vulnerability of farmers choosing the non-farming livelihood strategy is much higher than that of farmers choosing the part-time livelihood strategy and pure farming livelihood strategy. In Eastern Himalayan foothills of West Bengal, India, most farmers with medium and high resilience diversify their farming systems or switch from traditional staple grains to cash crops that consume less water (Pritha and Bhagirath, 2022). Additionally, it is found that the more experienced households tend to choose different adaptation strategies. This agrees with the findings of Uekusa and Matthewman (2017) and Marschke and Berkes (2006), who found that households with work experience are most likely to exhibit resilience.

Centralized resettlement households are more inclined to choose “expansion and adjustment” than “expansion and adjustment and assistance” as their strategy. The results indicate that after a relocated family moves to a new settlement, they tend to choose an adjustment strategy to seek higher incomes. This is not consistent with an earlier study by Diniz et al. (2013) that explored relocated households’ adaptation strategies in the Brazilian Amazon. Disaster avoidance relocation has a significant positive impact on the choice of expansion strategy. Our previous research showed that disaster avoidance relocation entails that due to environmental damage to the original living space, the resettled households are usually forced to choose adaptation strategies other than agriculture, such as going out to work to maintain their current livelihoods (Li et al., 2018; Liu et al., 2019). Ecological restoration relocation has a significant negative impact on

the choice of expansion and adjustment strategy, which is consistent with the study of Bernstein (2007), which showed that ecological restoration relocation involves migration from originally poor living conditions to areas with relatively good natural resource conditions; such households are more inclined to choose the expansion strategy to meet basic living needs. Centralized resettlement households are more likely to choose the expansion strategy, and have begun to shift from the original agriculture-led lifestyle to a broader non-agricultural way of subsistence, which can be an effective way to transform farmers into citizens (Li et al., 2017). The length of relocation time is a significant factor influencing the choice of adaptation strategy, and our results show that the adaptation strategy choices of long-term households are more extensive. This supports previous findings by Lo and Wang (2018) and Rogers et al. (2019) that highlighted the importance of post-resettlement support for the long-term success of resettlement projects.

Household size, skills training, physical capital, and government policies in livelihood capacity are also significant factors influencing the choice of adaptation strategies. Families with larger households prefer to choose the expansion strategy and the “expansion and assistance” strategy. This may be due to the fact that households have less access to urban-rural relocation or non-agricultural activities, so they tend to choose the expansion strategy. In addition, the larger household size may be due to larger households having more elderly or children, and this part of the population is mostly in a state of passive assistance. This supports the research of Marschke and Berkes (2006), and Sina et al. (2019b). Poverty alleviation policies have a significant positive impact on the choice of adaptation strategy, indicating that the implementation of government policies will directly encourage farmers to make better choices of adaptation strategy.

Our study has clear limitations. First, the evaluation indexes of relocated household livelihood adaptive capacity used in this paper are based on frameworks developed in foreign countries, and there are certain limitations in the choice of indicators, which need to be further verified and improved, such as not considering the impact of land expropriation on households' livelihood adaptive capacity and the choice of adaptation strategy. Second, the entropy method used in this paper determines the weight of each indicator. However, in order to pursue the accuracy of the data, we should adopt different analysis methods for comparison. Moreover, due to the limited survey data, this paper analyzes the current livelihood adaptive capacity and the choice of adaptation strategy, and does not discuss the evolution of households' future livelihood adaptive capacities and their choice of adaptation strategy. Third, the survey was conducted in Ankang Prefecture, southern Shaanxi, and results for livelihood adaptive capacity of relocated households in different areas may be different. Therefore, the

findings may only apply to undeveloped regions. Finally, we should also focus on adaptation strategies and outcomes in the context of disaster resettlement.

## Conclusion

This study assesses the livelihood adaptive capacity and analyzes the influencing factors of the choice of households' adaptation strategy. We see that, compared with the other four types of households, the livelihood adaptive capacity index of ecological restoration relocation households showed a normal distribution. Households with more than 5 years of relocation have the highest livelihood adaptive capacity, and the overall performance is high and balanced. There are differences in the livelihood adaptive capacity of farmers with different relocation approaches, with centralized resettlement households having lower livelihood adaptive capacities. The livelihood adaptive capacities of households choosing different types of adaptation strategy vary greatly, the most significant of which is the choice of “expansion and adjustment and assistance” strategy, whose households have the highest technical ability but relatively low economic resource capacity. The analysis of factors affecting households' adaptation strategy shows that some of the indicators among the relocation characteristics have an important impact on the choice of adaptation strategies. Those with centralized resettlement are more inclined to choose the “expansion and adjustment” strategy. Household size, skills training, products and tools, and the impact of government policies to alleviate poverty also have significant influences on the choice of adaptation strategy. In particular, poverty alleviation policies have a significant positive impact on the choice of adaptation strategy, indicating that the implementation of government policies will directly encourage households to make the best choice of adaptation strategy.

A potential contribution of this study is that the proposed framework may be a practical approach for resettlement communities to measure their livelihood adaptive capacities and to identify areas that need to be strengthened at the household level. In addition, this article adds value to existing livelihood adaptation strategy research by offering a quantitative approach for evaluating livelihood adaptation strategy for relocated households in disaster resettlement. Given the importance of the adaptive capacity of livelihoods, more research is needed concerning adaptation strategies and adaptation outcomes for disaster resettlement.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

WL: overall management, planning, and material preparation. YC and WL: proposal development. YC: editing and reviewing the manuscript. JL and WL: data collection and coordination. MF: review and editing. All authors read and approved the final manuscript.

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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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