

## Article

# Study on the Livelihood Vulnerability of the Poor Relocated Households in Karst Area: A Case Study of Liupanshui Area

Changxiang Wang<sup>1,2</sup>, Zhongfa Zhou<sup>1,2,\*</sup>, Quan Chen<sup>1,2</sup>, Qing Feng<sup>1,2</sup> and Changli Zhu<sup>1,2</sup><sup>1</sup> Karst Research Institute, Guizhou Normal University, Guiyang 550001, China<sup>2</sup> National Engineering Technology Research Center for Karst Rocky Decertification Control, Guiyang 550001, China

\* Correspondence: fa6897@gznu.edu.cn

**Abstract:** Relocation for poverty alleviation has become a vital means for the elimination of rural poverty in China. Research on livelihood vulnerability and its influencing factors of relocated farm households before and after poverty alleviation in Karst areas would contribute to the sustainable development of rural households in mountainous areas, which remains unclear. In this paper, the livelihood vulnerability evaluation index system and evaluation model in Karst areas were constructed based on questionnaire data of relocated households in Liupanshui collected in 2020. Then, the degree of livelihood vulnerability of households before and after relocation was measured, and the analysis of the difference between livelihood vulnerability index and dimension of households with different resettlement methods, relocation time, and livelihood diversification index was carried out in detail. Afterward, stepwise linear regression analysis was chosen to screen the main factors affecting the livelihood vulnerability of rural households subject to different resettlement methods and different relocation time. Results show that the livelihood vulnerability of rural households decreased significantly after relocation, and the risk of rural households returning to poverty was reduced. At the same time, it reveals that the family income level and livelihood diversification index have significant positive effects on the livelihood vulnerability index of rural households before and after relocation. In addition, among the three village resettlement methods, urban resettlement is the most effective way to alleviate the livelihood vulnerability of rural households. With increasing time since relocation, the adaptability of rural households to the new environment is enhanced, and their ability to withstand the impact of risks is also significantly improved.

**Keywords:** livelihood vulnerability assessment; relocation for poverty alleviation; stepwise linear regression; livelihood diversification index



**Citation:** Wang, C.; Zhou, Z.; Chen, Q.; Feng, Q.; Zhu, C. Study on the Livelihood Vulnerability of the Poor Relocated Households in Karst Area: A Case Study of Liupanshui Area. *Agriculture* **2022**, *12*, 1577. <https://doi.org/10.3390/agriculture12101577>

Academic Editors: Alvydas Baležentis, Tomas Baležentis and Dalia Štreimikienė

Received: 2 September 2022

Accepted: 27 September 2022

Published: 30 September 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Relocation for poverty alleviation is a national rural development policy, and resettlement and integration is regarded as a vital tool to resolving environmental and poverty-related issues and the contradictions in human–land relations. In a certain time and space, it can be seen as an effective way to implement fixed-point poverty alleviation strategy, and to provide time capital for ecological restoration in the relocated areas [1]. As the main subject of relocation, it is particularly important to evaluate and analyze the mechanism of the effect of relocation policies for poverty alleviation through the perspective of household livelihoods. The choice of livelihood strategies and the reset of livelihood capital of farm households after relocation directly reflect the implementation effect of the policies. In recent years, with the development of sustainable livelihoods, scholars have paid more attention to the study of livelihood aspects of relocation for poverty alleviation, mainly focusing on livelihood capital, livelihood strategies, and livelihood stability [1,2]. The livelihood capital of migrant families generally increased after relocation, and the diversification of livelihood strategy makes nonfarming continue for peasant households [3]. The

increase in the duration of relocation and the implementation of corresponding policies can facilitate the transformation of livelihood strategies of households; as a result, household income is dominated by nonfarm income [4,5]. Previous studies have shown that the community characteristics and livelihood activities of farm households after relocation have a significant impact on whether they fall into poverty [6]. After relocation, households may face new risk shocks and they are more likely turn to poverty. In this situation, the most important concern is whether households could reduce their livelihood vulnerability after relocation. Thus, it is of vital importance to explore and analyze the policies of poverty alleviation and relocation from the perspective of livelihood vulnerability.

Previous studies illustrate that the study of livelihood vulnerability has now become an important analytical tool for measuring ecological changes and farm households' coping capacity in key areas [7–9], while the research hotspots of vulnerability have gradually shifted from natural ecosystems to the coupling of human–earth relationships. In terms of the progress of the livelihood vulnerability research, foreign research hotspots have shifted from serving political economy to development policies and social–ecological systems of society [10–12]. Scholars such as Shah et al. focused on reducing livelihood vulnerability in developing countries and areas dependent on regional resources for development [13]. Hahn et al. used livelihood vulnerability to assess climate change in Mozambique region, and Martin et al. paid attention to farm livelihoods of farming and herding households in arid areas [14,15]. At the same time, livelihood vulnerability studies in China have shifted in recent years from ecological environment to sustainable development [4]. Scholars such as Yan Jianzhong generally made targeted recommendations for farming and herding groups on the Qinghai–Tibet Plateau; Luo Chengping and others mainly outlined the characteristics of ecological vulnerability and made outstanding contributions for reducing livelihood vulnerability in areas with interlocking agricultural and pastoral zones. Yin Haodong et al. analyzed the environment of farm households and the communities in which they live, and demonstrated that the type and mode of livelihood activities they mainly engage in have an important impact on assessing if the farm household is poor. Zhao Xueyan et al. explained in detail the livelihood sustainability of farm households in the middle and upper reaches of the Yellow River and the key ecological function areas in southern Gansu [16]. It should be noted that although the study of livelihood vulnerability from a large regional scale at the national level has been done extensively, the microscale changes in livelihood capital and social relations of farmers are easily ignored [17]. Thus, livelihood vulnerability studies have gradually shifted in recent years to communities and farm households.

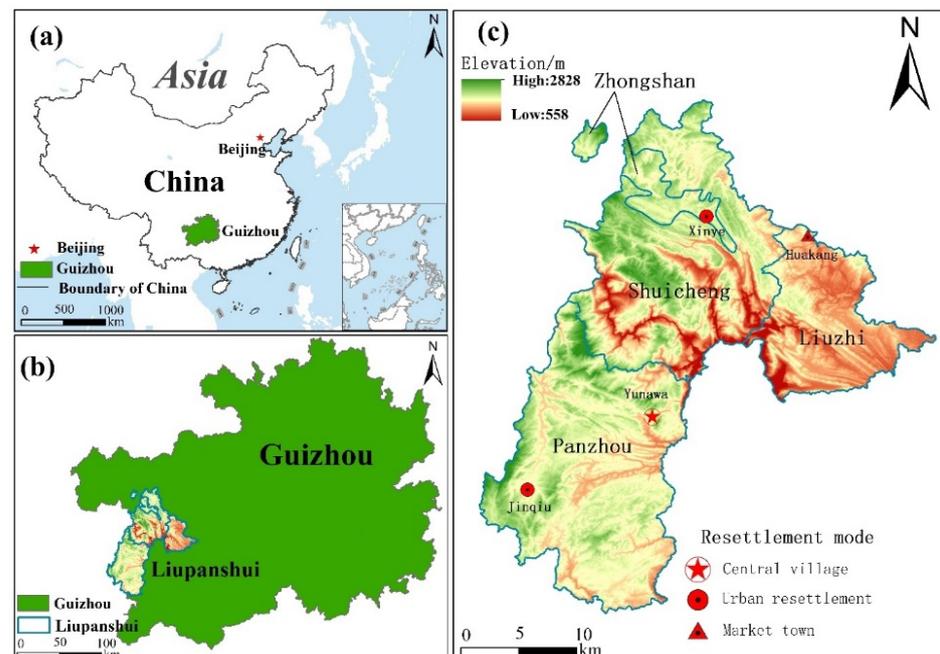
During the 13th five-year plan, the national relocation plan for poverty alleviation included nearly 10 million people, and a total of 1,151,600 poverty-stricken people were assigned to Guizhou Province in the relocation plan, which directly leads to Guizhou as the province with the largest relocation scale and the heaviest task in China. Since 2016, the relocation strategy for poverty alleviation entered the consolidation stage, and the relocation in Guizhou province was basically complete by April 2020. Monitoring and evaluating the changes in production and life of farm households after relocation can provide a scientific basis for subsequent policy development and development planning. Concerning Liupanshui City, located in Guizhou Province, there are three relocation methods, which include town relocation, collector town relocation, and central village relocation; further, relocation encompasses a wide time span (2016–2019) and various livelihoods of the resettled farm households, which is highly representative of the entire Karst region. For these reasons, Liupanshui was taken as the study object—the study of the livelihood vulnerability of relocated farmers would provide experience and theoretical guidance for further promoting the follow-up work of poverty alleviation relocation in Karst areas. Currently, owing to the unique geographical background, scholars mainly focus on the changes in farm household livelihood capital and the optimal choice of livelihood strategies after relocation, as well as the effects of different landscapes on farm household livelihood vulnerability in Karst areas [2]. There are fewer quantitative analyses that combine livelihood vulnerability

with poverty alleviation relocation that compare livelihood vulnerability before and after relocation. Based on the research on livelihood vulnerability conducted by scholars in China and abroad, this paper provides the theoretical basis and analysis method for this study. The study aims to identify the effect of different resettlement methods on livelihood vulnerability and the changes in livelihood vulnerability through time, and then provides a scientific basis for the subsequent policy formulation and development planning for poverty alleviation relocation in Karst areas.

## 2. Materials and Methods

### 2.1. Study Area Overview

Liupanshui City is located at the junction of two contiguous special hardship areas, the Wumeng Mountains and the Yunnan–Guizhou–Guizhou–Guizhou Stone Desertification Zone, as shown in Figure 1, and it contains four county-level administrative districts, namely Zhongshan District, Panzhou City, Liuzhi Special Zone, and Shuicheng County. Figure 1a,b show the position of Guizhou Province in Asia and the location of Liupanshui City in Guizhou Province, respectively, and the locations of four county-level administrative districts are shown in Figure 1c. The proportion of Karst areas in Liupanshui City is 63.118%, with an overall altitude of 1200~2000 m. Liupanshui is rich in mineral resources and has a wide distribution of ethnic minorities, and has a high elevation and abundant precipitation. The total relocation population in Liupanshui is 116,165.



**Figure 1.** Location and structures of the study area.

### 2.2. Data Sources

The participatory rural appraisal method was adopted in this paper by entering the farmers' homes and distributing questionnaires to them directly, which could effectively avoid the possible errors caused by using indirect data analysis. In order to focus on all-around changes before and after relocation of farming families, as shown in Table 1, the questionnaire was mainly set up with five aspects: basic family information, basic situation of family members, production conditions before and after relocation, expenditure status before and after relocation, and satisfaction survey.

**Table 1.** Questionnaire information.

| Basic Household Information of Farmers     | Basic Information of Household Members                     | Production Conditions before and after Relocation | Expenditure before and after Relocation  | Satisfaction Survey                         |
|--|--|---|--|---|
| Whether to establish a file card household | The relationship between the member and the household head | Living conditions                                 | Cost of daily living                     | Personal sense of well-being                |
| Relocation time of farmers                 | Gender, age, national, marital status                      | Arable land, woodland, land circulation           | Cultivation and breeding expenditure     | Satisfaction with living environment        |
| Record the year of poverty alleviation     | Health, level of education, labor capability               | Growing income, farming income                    | Education spending, transportation costs | Satisfaction with public service facilities |
| The original residence of the farmer       | Professional, income, work months                          | Work income, government subsidies                 | Health spending                          | Satisfaction with convenient transportation |
| The current residence of the farmer        | Working place, employment channels                         | Profit sharing of cooperatives, loan              | Medical insurance, endowment insurance   | Satisfaction with government services       |

A total of 150 questionnaires were distributed to four representative resettlement communities in the Liupanshui area, as shown in Table 2, which contain about 1500 farming families. Then, 141 valid questionnaires were recovered, with an effective rate of 94%. The questionnaires could provide a comprehensive understanding of the possible risks faced by farming families.

**Table 2.** Study area overview.

| Region    | Resettlement Mode  | Resettlement Community | Relocation Time | Number of Questionnaires |
|-----------|--------------------|------------------------|-----------------|--------------------------|
| Panzhou   | Urban resettlement | Jinqiu                 | 2018            | 40                       |
| Panzhou   | Central village    | Yunawa                 | 2016            | 12                       |
| Liuzhi    | Market town        | Huakang                | 2016            | 39                       |
| Shuicheng | Urban resettlement | Xinye                  | 2019            | 50                       |

### 2.3. Research Methods

Summarizing previous studies, there are currently three main analytical frameworks for livelihood vulnerability: analytical frameworks oriented to the mechanism of the action process, analytical frameworks which address the evaluation of vulnerability levels, and analytical frameworks that address supported decision-making. The main methods of livelihood vulnerability evaluation include participatory rural appraisal, integrated index, functional model, and BP artificial neural network [4]. The “exposure–sensitivity–adaptability” analysis framework of IPCC (Intergovernmental Panel on Climate Change) has been widely used for community-scale vulnerability studies.

In this study, to eliminate the influence of different scales and units in the original questionnaire data, the data were standardized by using the extreme difference standardization method, and the weights of each indicator were determined by using the entropy method.

The IPCC’s “exposure–sensitivity–adaptability” analytical framework [17] was adopted in this paper, which uses a hierarchical approach to organize the indicator system and strictly standardizes the assessment process and steps to make the assessment results inductive and comparable. The framework has been widely used in many fields of vulnerability research, and it can be found from previous literature that there are not many vulnerability studies from the perspective of farm households at the community scale. Based on the relevant studies and some characteristics of the relocated households, and taking into account their understanding and recognition of the policy, this paper develops a system

of indicators based on the exposure, sensitivity, and adaptability of the households (see Table 3) to evaluate the impact of the relocation policy on the livelihood vulnerability of relocated households in a more comprehensive and objective manner from all perspectives of the households, in order to provide some reference for future relocation work in Karst areas. The results are presented in Table 3 [18].

**Table 3.** Livelihood vulnerability evaluation index system.

| Index System Dimension | Indicators                                   | Index Weight | Index Interpretation and Assignment Methods  | Mean Indicators | Index Is Positive or Negative |
|------------------------|--|--------------|--|-----------------|-------------------------------|
| Exposure               | Degree of family aging                       | 0.0018       | Proportion of households over 70 years old   | 0.049           | Negative                      |
|                        | Degree of family illness and disability      | 0.0028       | Number of family members who have lost the ability to work   | 0.539           | Negative                      |
|                        | Agricultural and forestry loss               | 0.0025       | Loss of income from farming and breeding   | 4464.096        | Negative                      |
|                        | Property damage                              | 0.0085       | Amount of asset loss   | 4257.801        | Negative                      |
|                        | Loss of land property                        | 0.0013       | Area of abandoned land   | 0.121           | Negative                      |
| Sensitivity            | Health status of family members              | 0.002        | The percentage of medical expenses in household income <20% was 0.33, and the percentage of medical expenses in household income between 20% and 50% was 0.67 and above 50% was 1.00 | 0.347           | Negative                      |
|                        | Degree of dependence on education            | 0.0024       | The percentage of family income spent on children's schooling  | 0.066           | Negative                      |
|                        | Custom spending                              | 0.0506       | Below 1000 is 0.1. Every increase of 1000 goes up 0.1 and above 10,000 is 1  | 0.353           | Positive                      |
|                        | Degree of income dependence                  | 0.0048       | Agriculture and forestry income in the proportion of household income  | 0.028           | Negative                      |
|                        | Food dependence degree                       | 0.0162       | The percentage of food purchased in a year in household income <20% is 0.33, 20~50% is 0.67 $\geq$ 50% is 1.00   | 0.586           | Negative                      |
|                        | Safety of drinking water                     | 0.0428       | 0 if there is tap water and 1 if not   | 0               | Negative                      |
|                        | Energy dependence degree                     | 0.0811       | 0 for electricity or natural gas, 1 otherwise  | 0               | Negative                      |
| Adaptability           | Per capita income                            | 0.0203       | Net household income per capita  | 12,513.050      | Positive                      |
|                        | Average years of schooling of family members | 0.0099       | Average years of schooling for all family members  | 6.196           | Positive                      |
|                        | Family burden ratio                          | 0.0023       | (Under 18 + over 70)/number of workers   | 0.841           | Negative                      |
|                        | Per capita cultivated land area              | 0.0705       | Per capita cultivated land area  | 1.182           | Positive                      |
|                        | Housing area                                 | 0.0248       | Family housing area  | 101.385         | Positive                      |
|                        | Credit capital                               | 0.1176       | Whether the farm household has bank loans  | 0.220           | Positive                      |
|                        | Have you received any training               | 0.0667       | If a family member receives skill training, it is 1, otherwise it is 0   | 0.454           | Positive                      |
|                        | Trust in the people around you               | 0.0019       | Very distrustful is 5; comparative distrust is 4; generally 3; comparative trust is 2; trusting is 1   | 1.936           | Positive                      |
|                        | Social network                               | 0.1334       | Whether there are any public officials in the family   | 0.135           | Positive                      |
|                        | Satisfaction with family income              | 0.0592       | Satisfied = 1; Dissatisfied = 0  | 0.496           | Positive                      |

Table 3. Cont.

| Index System Dimension | Indicators                       | Index Weight | Index Interpretation and Assignment Methods  | Mean Indicators | Index Is Positive or Negative |
|------------------------|----------------------------------|--------------|--|-----------------|-------------------------------|
|                        | Convenience of living            | 0.0545       | If yes, it is 1, if no, it is 0  | 0.879           | Positive                      |
|                        | Degree of policy understanding   | 0.0167       | If yes, it is 1, if no, it is 0  | 0.901           | Positive                      |
|                        | Livelihood Diversification Index | 0.1183       | The number of source channels of household income  | 1.397           | Positive                      |
|                        | Degree of policy support         | 0.0873       | No government subsidy is 0; 20 percent or less of household income is 0.2; aid is 0.5 for 20% to 50% of household income and 1 for more than 50% | 0.284           | Positive                      |

Note: The mean value and standard deviation are calculated using the value after relocation. Among them, the data used before and after relocation are the same for the degree of family aging and the degree of family illness and disability, agricultural and forestry loss, property loss, land and property loss, per capita years of education, whether to receive training, trust degree of surrounding people, satisfaction degree of family income, convenience of living and policy understanding.

The integrated index assessment model is simple to operate and easy to understand, which can reflect the magnitude of the farmers' livelihood vulnerability index more intuitively, and has been widely used in the calculation of livelihood vulnerability index. The model can be presented as follows:

$$LVI = (E + S) - A \quad (1)$$

where *LVI* is the livelihood vulnerability index, *E* is the degree of exposure, *S* is the degree of sensitivity, and *A* represents the adaptive capacity.

### 3. Results

#### 3.1. Descriptive Statistical Analysis

##### 3.1.1. Farm Household Type Division

The purpose of this study is to identify the characteristics and reasons for relocated farm households to alleviate poverty; thus, it is necessary for classifying types of relocated farm households according to a certain condition. Based on the collected data and research results of previous literature, the relocation methods of farm households are firstly divided into three types according to policy requirements, including urban relocated farm households, market-town relocated farm households, and central-village relocated farm households. At the same time, these relocated farm households could also be classified by their relocation time, including recently relocated farm households, 2–3 year-relocated farm households, and more than 3-year-relocated farm households. Meanwhile, according to the per capita net income of relocated households, they can be classified into low-income households (per capita net income of households is less than 50% of the sample average), middle-income households (per capita net income of households is more than 50% of the sample average and less than the sample average), and high-income households (per capita net income of households is more than the sample average). Referring to the survey results, the two main sources of income for farm households are income from labor and farming/forestry, which can be divided into pure agricultural income, nonagricultural income, and multiple income sources. In addition, according to the diversification of income sources, the relocated households can be classified into single livelihood households, two livelihood households, and multiple livelihood households. Referring to [10], the livelihood activities in which the household participated were assigned various values, i.e., the households with one income source were assigned 1, those with two income sources were assigned 2, while larger numbers represented households with more than two income sources. Since the income sources of farm households may change before and after reloca-

tion, these classification types are more useful to quantify the impact of poverty alleviation and relocation policies on livelihood vulnerability of farm households.

In general, the net income per capita of farm household members, together with the number of years of education per capita, the average area of cultivated land, and the area of housing, are directly proportional to the household's adaptive capacity; the higher the adaptive capacity of farm households, the lower the shock in face of risk and the higher their selectivity. Similarly, the more the annual income of farm households is spent on children's education, social customs, medical care, etc., and the greater the aging of the household, then the higher the relative exposure and sensitivity of the farm household would be, and the greater the difference between the sum of the two and the adaptive capacity. In this situation, the livelihood vulnerability of farm households would also be increased, which would lead to the higher shock when facing various risk conflicts, and they would fall into the vicious circle of poverty more easily [12,19,20].

### 3.1.2. Farm Household Type Division

According to the above classification of farm household types, it is now possible to make a simple analysis of the basic information of farm households. As referring to the 141 households studied, 90 (63.8%) were relocated to towns, 39 (27.7%) to market towns, 12 (8.5%) to central villages; 49 (34.8%) were relocated recently, 50 (35.5%) were relocated 2–3 years ago, and 42 (29.7%) were relocated in more than 3 years ago. Further, it is worth noting that all relocated households living in Yunawa were relocated more than three years ago. The number of households with a single livelihood activity before relocation was 106 (75.2%), 34 (24.1%) for households with two livelihood activities, and 1 (0.7%) for households with multiple livelihood activities. Since relocation may have changes and impacts on the livelihood activities of the farmers, 87 (61.7%) of the households were single livelihood type, 52 (36.9%) of the households were two livelihood types, and 2 (1.4%) of the households were diversified livelihoods after relocation. This is closely related to the relocation policy of Guizhou Province, which adopts the relocation policy of urban resettlement as the main center of village resettlement and town resettlement as the supplement. This is closely related to the relocation policy of Guizhou Province, which adopts urban resettlement as the main center village resettlement and town resettlement.

From Table 4, it can be seen that there are differences in the degree of family disability, income dependence, per capita net income, and family burden ratio among relocated farm households with different income levels in Liupanshui area. On the one hand, there were 33 low-income households, 51 middle-income households, and 57 high-income households that were relocated before the relocation, and 19 low-income households, 69 middle-income households, and 53 high-income households that were relocated after the relocation. On the other hand, the per capita net income of all types of income households was greatly increased after the relocation, which showed that the relocation had large impact on the relocated households. It can be deduced from these results that the relocation had a greater impact on the relocated households. Meanwhile, the low-income households were RMB 3424.414 and RMB 5062.319, respectively, before and after the relocation; taking the high-income households as examples, their incomes were RMB 16,431.8 and RMB 19,397.092, respectively, which also reveals that the household income gap is too high (rich–poor gap) for the same relocated households. The main reason why the livelihood dependence of high-income farm households was lower while their livelihood vulnerability was higher is greater dependence on household income from labor, which has a strong instability. The livelihood vulnerability of middle-income and high-income farm households declined significantly after relocation, which is closely related to the stable income source of farm households after relocation and the low level of household sickness and disability. It could be found that most of the resettlement communities have taken measures to arrange for relocated farm households to work in community factories or other nearby jobs, which has undoubtedly enhanced the income stability of farm households.

Farm household income tends to be nonfarm after relocation, and most farm households adopt land transfer and return to farming during holidays to obtain additional income.

**Table 4.** Basic information of rural household characteristics before and after relocation.

| Rural Household Type                       | Degree of Family Illness and Disability | Degree of Income Dependence | Per Capita Income | Per Capita Cultivated Land Area | Livelihood Vulnerability |
|--|---|-----------------------------|-------------------|---------------------------------|--------------------------|
| Low-income households before relocation    | 0.758                                   | 0.208                       | 3424.414          | 1.146                           | 1.047                    |
| Low-income households after relocation     | 0.421                                   | 0.009                       | 5062.319          | 1.241                           | 1.27                     |
| Middle income households before relocation | 0.47                                    | 0.152                       | 7512.6            | 0.946                           | 0.766                    |
| Middle income households after relocation  | 0.811                                   | 0.026                       | 9276.959          | 0.888                           | 1.063                    |
| High income households before relocation   | 0.473                                   | 0.11                        | 16,431.8          | 0.568                           | 1.047                    |
| High income households after relocation    | 0.226                                   | 0.037                       | 19,397.092        | 0.635                           | 1.305                    |

### 3.2. Vulnerability Analysis of Farmer Livelihoods with Poverty Alleviation and Relocation

#### 3.2.1. Comparative Analysis of Livelihood Vulnerability before and after Relocation

Vulnerability values reflect the adjustment and adaptive capacity of farm households in the face of various natural and socioeconomic risks, and reflect a tendency for sustainability of farm households. According to the model in this paper, a positive and larger value of farm household livelihood vulnerability indicates a higher level of exposure and risk for farm households, and the adaptive capacity and farm household livelihood would be poorer and more vulnerable, respectively. In contrast, a negative value of farm household livelihood vulnerability indicates that the farm household has a stronger adaptive capacity. Additionally, based on the division of farm household samples, there are large differences in livelihood vulnerability of farm households with different resettlement methods, relocation times, income levels, and livelihood patterns.

As shown in Table 5, the level of livelihood vulnerability of farm households before and after relocation is generally in the range 0.2–0.5, which indicates that the overall adaptive capacity of samples in the study area is strong, and it also reveals that the level of livelihood vulnerability of farm households in the area varies greatly. Farmers' livelihood vulnerability reached its lowest level in 2–3 years after relocation, and then slightly increased more than 3 years after relocation, but it is still lower than the recent relocation, indicating that the level of livelihood vulnerability of farm households fluctuates over time, and relocation to new resettlement sites has a fundamental ability to improve farm household livelihoods in the long run. Furthermore, the exposure level of relocated farm households reaches the lowest degree when the duration of relocation time is more than three years, while the sensitivity is also higher than that in the duration of relocation time between two to three years, and the adaptive capacity is also lower. This phenomenon might be largely due to the increasing dependence of farm households on outwork income and the gradual reduction in income from primary industries, which leads to the irrationality of farm household income structure. However, as the time of relocation increases, the ability of farm households to adapt to the local environment is strengthened, the nonfarm income becomes more stable, and the livelihood vulnerability of farm households tends to decrease along with the increase in livelihood diversification. Overall, the level of livelihood vulnerability of farm households presents a spiral upward trend through time, and poverty alleviation relocation has a fundamental significance to enhance the sustainable development ability of farm households in the long run.

**Table 5.** Analysis of the exposure level, sensitivity, adaptive capacity, and livelihood vulnerability of households with different relocation time and different livelihood activities.

| Relocation Time and Number of Livelihood Activities | Exposure | Sensitivity | Adaptability | Livelihood Vulnerability |
|---|----------|-------------|--------------|--------------------------|
| Recently relocated farm households                  | 0.0138   | 0.0414      | 0.2137       | −0.1585                  |
| Farm households relocated 2–3 years                 | 0.0236   | 0.0280      | 0.2876       | −0.236                   |
| Farm households relocated more than 3 years         | 0.0084   | 0.0292      | 0.2187       | −0.1811                  |
| Single source farm household                        | 0.0082   | 0.0281      | 0.2242       | −0.1879                  |
| Two sources of subsistence farm families            | 0.0086   | 0.0411      | 0.2620       | −0.2123                  |
| Multiple sources of livelihood farm families        | 0.0073   | 0.0337      | 0.4520       | −0.411                   |

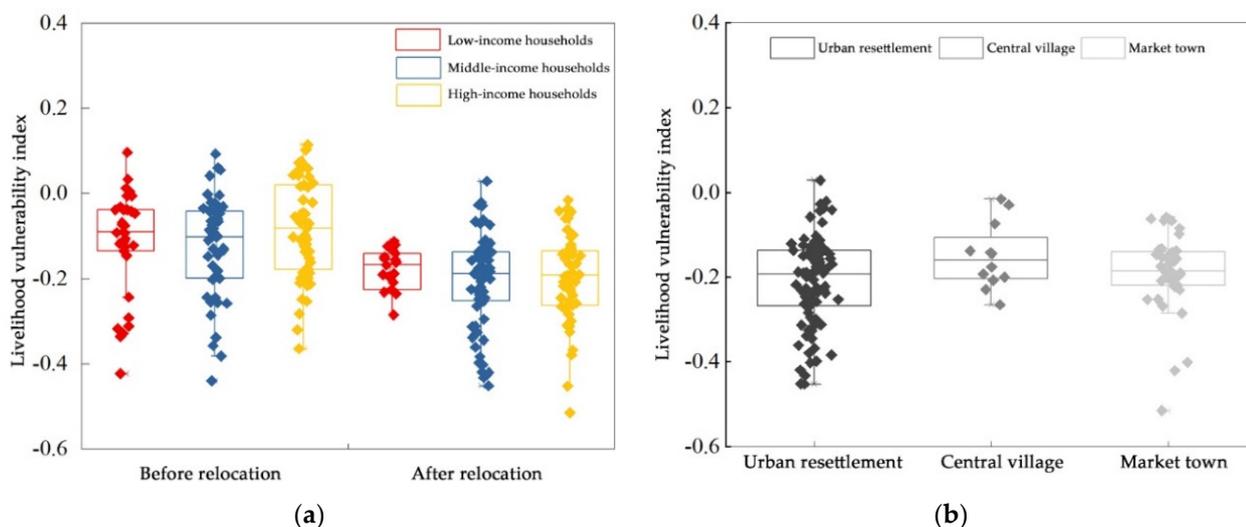
### 3.2.2. Comparative Analysis of Household Livelihood Vulnerability of Farm Households with Different Livelihood Activities

Table 5 illustrates that the number of types of livelihood activities engaged by farm households has a large impact on the exposure level, sensitivity, adaptive capacity, and livelihood vulnerability of farm households. It is clear from Table 5 that farm households with only one income source have the lowest adaptive capacity and the highest livelihood vulnerability, and they are less able to resist the impact of natural and socioeconomic factors. Based on the questionnaire survey, it is assumed that the possible reasons are that the households relying on agricultural cultivation and farming income are more deeply affected by weather and natural disasters, and the impact on household income is increased when agricultural production is reduced. The increase in the numbers of farm households with two income sources after relocation is mainly due to the introduction of many small industrial enterprises by the government in the resettlement communities, which promotes local employment of local labor. The diversification of income sources for farm households can effectively help farm households face various risk shocks confidently. At the same time, the mean value of livelihood vulnerability of farm households in all three livelihood types after relocation is negative, which indicates that the overall livelihood vulnerability level in the resettlement area improved after relocation, and people's living standard also improved.

### 3.2.3. Comparative Analysis of Different Income Types and Different Placement Methods

The livelihood vulnerability index of households with various incomes and resettlement modes before and after relocation were shown in Figure 2a and Figure 2b, respectively. It can be seen obviously that the distribution in livelihood vulnerability indices for the three income levels before relocation is relatively discrete, and the gap between the maximum and minimum values is large. This result indicates that the relocation plays a crucial role in poverty alleviation, and the minimum values of the three income levels are significantly lower, which indicates that the relocation has a strong effect on improving the livelihood vulnerability of farm households and enhancing their ability to face risk shocks. In the process of poverty alleviation and relocation in Guizhou Province, the strategies of urban resettlement as the priority, and market towns and central villages as the supplement, were adopted. The livelihood vulnerability level of urban resettlement is relatively intensive and the overall level tends to increase among the samples. This is probably due to the fact that the income of farm households increased, and education and medical conditions improved after relocation, which promotes the enhancement of the overall adaptive capacity of farm households. Furthermore, in the long run, the distribution of resettlement in towns is more

concentrated and the upper limit of development potential of subsequent farm households is higher.



**Figure 2.** Livelihood vulnerability index of households with different income types and resettlement methods.

### 3.3. Livelihood of the Relocated Farm Households

#### 3.3.1. Evaluation of the Impact Factors of Livelihood Vulnerability before and after Relocation

Based on existing domestic and international research, it is confirmed that the main factors affecting the livelihood vulnerability of farm households can be summarized as follows: the years of education of household members, the types of livelihood activities engaged by farm households, the income of farm households, the level of trust in the people around the place of residence, and the various risks faced by farm households, and so on. In this paper, the indicator system was used as explanatory variables based on previous studies to assess and analyze the livelihood vulnerability before and after relocation, along with the livelihood vulnerability of different resettlement methods and resettlement time using stepwise linear regression models, respectively. The goodness-of-fit  $R^2$  of the eight models are 99.9%, 99.8%, 67.2%, 99.9%, 99.9%, 99.9%, 99.9%. The results of the inflation factor validation of the simultaneous variables indicated that there was no multicollinearity among the respective variables, and each model passed the significance test. The specific results were shown in Tables 6 and 7.

Studies have highlighted the significant impact of household size on the mitigation of livelihood vulnerability [21]. According to Table 6, the sensitivity and adaptive capacity of farm households have a significant impact on livelihood vulnerability both before and after relocation, and the social capital and human capital possessed by farm households have a significant positive effect on mitigating the various risks and shocks encountered. All explanatory variables are positively and negatively correlated at the 1% statistical level, indicating that these explanatory variables have a significant impact on farm households in the group of relocated poor. The fact that energy dependence and water security are no longer the main factors affecting the livelihood vulnerability of farm households after relocation is inferred from the fact that most farm households use electricity or natural gas after relocation and have a guaranteed source of drinking water. Meanwhile, the presence of public officials in farm households has a significant positive effect on enhancing the adaptive capacity of households, which is beneficial to enhancing the adaptive capacity of household members to various relocation policies. Since relocation is a top-down project led by the government, national and local policies as well as the subsidies enjoyed by farmers, such as low-income insurance, have a direct impact on the adaptive capacity and livelihood vulnerability of farmers. The impact of livelihood diversification index on

reducing the livelihood vulnerability of farm households is significantly higher after relocation, and most farm households have strong demand for nonagricultural transition after relocation. This also reminds the government to pay more attention to the employment issues of the relocated households and to popularize the implementation and interpretation of various policies. Since there are many ethnic minorities living in the relocated areas, participation in various customary activities is an important expense for relocated households, and customary expenses have a significant negative impact on the livelihood vulnerability of them.

**Table 6.** Assessment results of influencing factors of livelihood vulnerability before and after household relocation.

| Explanatory Variables            | Vulnerability of Livelihoods Prior to Relocation | Vulnerability of Livelihoods after Relocation |
|----------------------------------|--|---|
| Social network                   | −0.133 ***                                       | −0.133 ***                                    |
| Credit capital                   | −0.118 ***                                       | −0.118 ***                                    |
| Whether to receive training      | −0.067 ***                                       | −0.067 ***                                    |
| Convenience of living            | −0.054 ***                                       | −0.055 ***                                    |
| Satisfaction with family income  | −0.059 ***                                       | −0.059 ***                                    |
| Degree of policy support         | −0.087 ***                                       | −0.087 ***                                    |
| Livelihood diversification Index | −0.059 ***                                       | −0.118 ***                                    |
| Custom spending                  | 0.056 ***  | 0.051 ***                                     |
| Per capita cultivated land area  | −0.006 ***                                       | −0.071 ***                                    |
| Degree of policy understanding   | −0.017 ***                                       | −0.017 ***                                    |
| Food dependence degree           | 0.024 ***  | 0.016 ***                                     |
| Housing area                     | $-6.526 \times 10^{-5}$ ***                      | −0.025 ***                                    |
| Energy dependence degree         | 0.081 ***  |   |
| Safety of drinking water         | 0.043 ***  |   |
| R <sup>2</sup>                   | 99.9%  | 99.8%   |

Note: \*\*\* represents statistical significance at the 1% level.

**Table 7.** Evaluation results of influencing factors of livelihood vulnerability in different resettlement methods and different relocation time.

| Explanatory Variables            | Central Village | Market Town | Urban Resettlement | Recently Relocated Farm Households | Farm Households Relocated 2–3 Years | Farm Households Relocated More than 3 Years |
|----------------------------------|-----------------|-------------|--------------------|------------------------------------|-------------------------------------|---|
| Convenience of living            | −0.110 **       |             | −0.055 ***         | −0.055 ***                         |                                     | −0.054 ***                                  |
| Satisfaction with family income  | −0.077 *        | −0.059 ***  | −0.059 ***         | −0.059 ***                         | −0.059 ***                          | −0.059 ***                                  |
| Social network                   |                 | −0.133 ***  | −0.133 ***         | −0.133 ***                         | −0.133 ***                          | −0.113 ***                                  |
| Whether to receive training      |                 | −0.067 ***  | −0.067 ***         | −0.067 ***                         | −0.067 ***                          | −0.067 ***                                  |
| Credit capital                   |                 | −0.118 ***  | −0.118 ***         | −0.118 ***                         | −0.118 ***                          | −0.118 ***                                  |
| Degree of policy support         |                 | −0.087 ***  | −0.087 ***         | −0.087 ***                         | −0.087 ***                          | −0.087 ***                                  |
| Livelihood Diversification Index |                 | −0.118 ***  | −0.118 ***         | −0.118 ***                         | −0.118 ***                          | −0.118 ***                                  |
| Per capita cultivated land area  |                 | −0.070 ***  | −0.071 ***         | −0.071 ***                         |                                     | −0.071 ***                                  |
| Degree of policy understanding   |                 | −0.017 ***  |                    |                                    | −0.017 ***                          | −0.017 ***                                  |
| Custom spending                  |                 | 0.051 ***   |                    | 0.051 ***                          | 0.051 ***                           | 0.051 ***                                   |

Table 7. Cont.

| Explanatory Variables          | Central Village | Market Town | Urban Resettlement | Recently Relocated Farm Households | Farm Households Relocated 2–3 Years | Farm Households Relocated More than 3 Years |
|--------------------------------|-----------------|-------------|--------------------|------------------------------------|-------------------------------------|---|
| Food dependence degree         |                 | 0.016 ***   | 0.016 ***          | 0.016 ***                          | 0.016 ***                           | 0.016 ***                                   |
| Housing area                   |                 | −0.025 *    | −0.025 *           | −0.025 *                           |                                     | −0.025 *                                    |
| Net income per capita          |                 | −0.010 *    | −0.020 *           | −0.020 *                           |                                     | −0.020 *                                    |
| Per capita years of education  |                 |             |                    |                                    | −0.010 *                            | −0.010 *                                    |
| Trust in the people around you |                 |             |                    |                                    |                                     | −0.002 *                                    |
| R <sup>2</sup>                 | 67.2%           | 99.9%       | 99.9%              | 99.9%                              | 99.9%                               | 99.9%                                       |

Note: \*\*\*, \*\*, and \* are statistically significant at 1%, 5%, and 10% levels, respectively.

### 3.3.2. Analysis of Factors Influencing Livelihood Vulnerability before and after Relocation

By 2020, the building of a moderately prosperous society in all respects was completed in China, and absolute poverty has been a circumstance of the past; the rural revitalization is a topic closely related to the livelihoods of farm households [22,23]. The analysis of the impact of different resettlement methods and relocation time on the livelihood vulnerability of farm households is important for guiding the subsequent sustainable development of farm household livelihoods in other areas as well as in the resettlement areas. According to the results provided in Table 7, it can be seen easily that the main factors affecting the livelihood vulnerability of farm households resettled in the central village are the convenience of living and household income satisfaction. Based on the data and interviews, it can be inferred that most of the relocated households in the central village are farming and working households, and their incomes are mainly from farming and working, especially from farming income. Since rural households still live in rural areas, they need to buy daily consumables to catch up with the market, so they have a strong demand for housing convenience. The choices of lifestyle and livelihood strategies of farm households in township resettlement are more similar to that of urban resettlement, so the factors affecting household livelihood vulnerability are repetitive. The income patterns of farm households in township and city resettlement tend to be diversified, and working outside the home becomes an important part of household income, which improves the livelihood capital of farm households, but the risk and exposure of farm households increase due to the improvement of the level of social security services and the limited educational level of the left-behind elderly and children. Urban resettlement is more influenced by the convenience of living than township resettlement, mainly by the demand for education and medical care. The livelihood vulnerability of urban resettled households is not affected by the level of policy understanding, since they have community committees to interpret national policies and have easier access to information.

Table 7 shows that the livelihood diversification index and social network of farm households for the three relocation time categories have a significant positive impact on alleviating the livelihood vulnerability of farm households. Thus, the government should focus on employment, skills training, and literacy improvement for farming families after relocation. According to the interviews with farmers, it is clear that the main factors affecting the livelihood vulnerability of farmers' families owe to the fact that recently relocated farmers urgently need to solve their children's education problems and local employment problems, which relate directly to their individual understanding of the relocation policy and their participation in skills training. This conclusion indicates that the government should not only generate income for farming families, but should also improve the level of social security and construction of public service facilities. As relocation

time passes quickly, there would be changes in livelihood strategy choices and adaptive capacity of farm households, and the factors affecting the livelihood vulnerability of farm households would also change over time. Fortunately, in general, the resilience to risk shocks and adaptive capacity of farm households clearly increases through time.

Through the study of the livelihood vulnerability of farm households in four resettlement communities in Liupanshui City, it was found that relocation is an effective mitigation measure for the Karst areas where the land could not support the entire low-income population. Furthermore, relocation has an important positive role in restoring the fragile ecological environment of the Karst areas and improving the sustainable livelihood capacity of the low-income people, thus making an outstanding contribution to solving the problem of human–land conflict. The choice of resettlement methods directly affects resettlement, and in the long run, urban resettlement is still the best choice for resettlement, which provides a good reference for other Karst areas worldwide. Meanwhile, after relocation, government policies should pay more attention to the sustainable development of farming families, and actively promote the integration of farming families in the relocation area.

#### 4. Discussion

In this paper, field research data concerning the exposure, sensitivity and adaptive capacity of farm households in relocation communities in Liupanshui City, Guizhou Province, were analyzed. The livelihood vulnerability of farm households before and after relocation was assessed by constructing a livelihood vulnerability evaluation system for relocated farm households in Karst areas and applying the livelihood vulnerability index. In order to identify the livelihood vulnerability characteristics of relocated farm households, this paper firstly divided the farm households into different types, and then analyzed the livelihood vulnerability indices before and after relocation for different relocation methods, relocation times, and types of farm households.

(1) Household income level has a significant positive effect on alleviating the livelihood vulnerability index of farm households, and the increase in income level also contributes to reducing the risk of poverty returning to farm households. Before relocation, the extreme values of the livelihood vulnerability index of the sample farm households differ widely and samples are more dispersed; however, after relocation, the overall livelihood vulnerability index of farm households is more clustered and their ability to resist risk shocks is significantly enhanced. After relocation, farm households gradually shift to nonfarming, and the livelihood diversification index has a fundamental impact on the reduction in farm households' livelihood vulnerability index. The richness of livelihood activities also affects farm households' exposure, sensitivity, and adaptive capacity. Considering the rugged terrain, shallow soil layer, and lack of surface water in Karst areas, which are not suited for the healthy development of agriculture, the pathway of farm household income source becomes particularly important.

(2) Relocation for poverty alleviation greatly enhances the adaptive capacity of farm households in low-income groups, and the livelihood vulnerability index of low-income farm households is all less than 0 after relocation. With the increase in relocation time, the exposure and sensitivity of farm households continue to decrease, adaptive capacity continues to improve, and livelihood vulnerability gradually decreases. In addition, this study found that the livelihood vulnerability index of farm households was lower than that of town resettlement and lower than that of central village resettlement when analyzed from the perspective of resettlement methods, and urban resettlement has a better effect as the main method of relocation for poverty alleviation in Karst areas. For building a moderately prosperous society, relocation to alleviate poverty plays a vital role in eliminating absolute poverty.

(3) Convenience of residence, household income satisfaction, social network, credit capital, livelihood diversification index, policy support, and whether to receive training are all important factors affecting the livelihood vulnerability of farm households. All of the following factors have a positive impact on reducing the livelihood vulnerability

of rural households relocated for poverty alleviation in Karst areas: effective measures such as rebuilding and rehabilitating the livelihood capacity of urban resettled farmers and optimizing the choice of livelihood strategies; continuously improving the level of social security and the construction of public service facilities; increasing the interpretation and popularization of national policies; and improving the human capital stock and social network of relocated rural households.

In addition, some policies might be formulated and developed in the future. The Government may strengthen financial support policies, such as encouraging farming families to actively start their own businesses and enhancing the ability of financial institutions to provide credit support. Meanwhile, the government may also strengthen land management policies, such as territorial and spatial planning for resettlement areas and returning forests to areas that were previously relocated. Moreover, public service policies might be strengthened by the government, such as increasing employment opportunities, improving employment support and the public service system in resettlement areas, and reducing the cost of education for farming families, among others.

## 5. Conclusions

Based on the study and analysis in this paper, the following recommendations are made.

(1) In response to the significant positive effects of household income satisfaction and livelihood diversification index on the livelihood vulnerability of relocated farmers, this paper suggests increasing social skills training for relocated farmers in resettlement areas after relocation to enhance the human capital accumulation of relocated farmers. At the same time, some measures should be taken, such as further expanding education investment, strengthening policy interpretation and explanation, providing guidance and training for relocated farmers to leave the industry, and continuously promoting resettlement area industrial support, guiding relatively low-technology industries such as agricultural processing industries into industrial parks, and gradually improving the adaptive capacity of relocated farmers. Moreover, the local government should take considerable action to promote the “urbanization” and “localization” of relocated farmers.

(2) For the newly relocated areas, the government should mainly solve the education and social security problems of the left-behind children and the elderly, increase the construction of public service facilities, and improve the medical and health conditions near the relocation communities. With the growth of relocation time, the government should continue to strengthen the follow-up governance of resettlement communities, optimize grassroots party organizations and residents’ self-governance organizations, continuously explore the advantageous resources of resettlement areas, improve the livelihood capacity of farmers themselves, and, finally, realize the sustainable development of farmers’ families.

(3) In view of nonagricultural migration promoted in urban resettlement areas, agricultural modernization in the resettlement of market towns and central villages should be continuously improved, and the implementation of the land transfer policy should be continuously promoted. In addition, the local government should provide corresponding advantageous policies to attract young talent to return to their hometowns for investment and construction development, cultivating local leading enterprises to increase job opportunities so as to transform farmers into workers.

**Author Contributions:** Conceptualization, Z.Z. and C.W.; methodology, C.W.; software, C.Z.; validation, Z.Z.; formal analysis, C.W.; investigation, C.W. and Q.F.; resources, Z.Z.; data curation, Z.Z. and Q.C.; writing—original draft preparation, C.W.; writing—review and editing, Z.Z. and C.W.; visualization, supervision, project administration, and funding acquisition, Z.Z. All authors have read and agreed to the published version of the manuscript.

**Funding:** National Natural Science Foundation of China Regional Project (41661088), Guizhou Province Philosophy and Social Science Planning Project (21GZZD39) and the High-Level Innovative Talents Training Program in Guizhou Province (2016-5674).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

## References

1. Kemkes, R.K. The role of natural capital in sustaining livelihoods in remote mountainous regions: The case of Upper Svaneti, Republic of Georgia. *Ecol. Econ.* **2015**, *117*, 22–31. [[CrossRef](#)]
2. Antwi-Agyei, P.; Dougill, A.J.; Fraser, E.D. Characterizing the nature of household vulnerability to climate variability: Empirical evidence from two regions of Ghana. *Environ. Dev. Sustain.* **2013**, *15*, 903–926. [[CrossRef](#)]
3. Su, F.; Ying, R.; Li, B. Visualization analysis of the hot topics and frontier on livelihood vulnerability research. *Sci. Geogr. Sin.* **2016**, *36*, 1073–1080.
4. Tong, L.; Zheng, K.; Su, F. Concept, analytical framework and assessment method of livelihood vulnerability. *Adv. Earth Sci.* **2020**, *35*, 209–217.
5. Arnall, A.; Thomas, D.S.; Twyman, C. Flooding, resettlement, and change in livelihoods: Evidence from rural Mozambique. *Disasters* **2013**, *37*, 468–488. [[CrossRef](#)]
6. Rezaul Islam, M. Climate change, natural disasters and socioeconomic livelihood vulnerabilities: Migration decision among the Char Land people in Bangladesh. *Soc. Indic. Res.* **2018**, *136*, 575–593. [[CrossRef](#)]
7. Unks, R.R.; King, E.G.; Nelson, D.R. Constraints, multiple stressors, and stratified adaptation: Pastoralist livelihood vulnerability in a semi-arid wildlife conservation context in Central Kenya. *Glob. Environ. Chang.* **2019**, *54*, 124–134. [[CrossRef](#)]
8. Heredia Salgado, M.A.; Säumel, I.; Cianferoni, A.; Tarelho, L.A.C. Potential for farmers' cooperatives to convert coffee husks into biochar and promote the bioeconomy in the North Ecuadorian Amazon. *Appl. Sci.* **2021**, *11*, 4747. [[CrossRef](#)]
9. Oluwagbemi, O.O.; Hamutoko, J.T.; Fotso-Nguemo, T.C.; Lokonon, B.O.K.; Emebo, O.; Kirsten, K.L. Towards resolving challenges associated with climate change modelling in Africa. *Appl. Sci.* **2022**, *12*, 7107. [[CrossRef](#)]
10. Ulrich, A.; Speranza, C.I.; Roden, P. Small-scale farming in semi-arid areas: Livelihood dynamics between 1997 and 2010 in Laikipia, Kenya. *Rural Stud.* **2012**, *28*, 241–251. [[CrossRef](#)]
11. Shameem, M.I.M.; Momtaz, S.; Rauscher, R. Vulnerability of rural livelihoods to multiple stressors: A case study from the southwest coastal region of Bangladesh. *Ocean Coast. Manag.* **2014**, *102*, 79–87. [[CrossRef](#)]
12. Mainali, J.; Pricope, N.G. Mapping the need for adaptation: Assessing drought vulnerability using the livelihood vulnerability index approach in a mid-hill region of Nepal. *Clim. Dev.* **2019**, *11*, 607–622. [[CrossRef](#)]
13. Shah, K.U.; Dulal, H.B.; Johnson, C.; Baptiste, A. Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. *Geoforum* **2013**, *47*, 125–137. [[CrossRef](#)]
14. Martin, R.; Linstädter, A.; Frank, K.; Müller, B. Livelihood security in face of drought: Assessing the vulnerability of pastoral households. *Environ. Model. Softw.* **2016**, *75*, 414–423. [[CrossRef](#)]
15. Hahn, M.; Riederer, A.; Foster, S.O. The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change—a case study in Mozambique. *Glob. Environ. Chang.* **2009**, *19*, 74–88. [[CrossRef](#)]
16. Zhao, X.; Mu, F.; He, X.; Su, H.; Jie, Y.; Lan, H.; Xue, B. Livelihood vulnerability of farmers in key ecological function area under multiple stressors: Taking the Yellow River water supply area of Gannan as an example. *Acta Ecol. Sin.* **2020**, *40*, 7479–7492.
17. Polsky, C.; Neff, R.; Yarnal, B. Building comparable global change vulnerability assessments: The vulnerability scoping diagram. *Glob. Environ. Chang.* **2007**, *17*, 472–485. [[CrossRef](#)]
18. Angeona, V.; Bates, S. Reviewing composite vulnerability and resilience indexes: A sustainable approach and application. *World Dev.* **2015**, *72*, 140–162. [[CrossRef](#)]
19. Singh, P.K.; Nair, A. Livelihood vulnerability assessment to climate variability and change using fuzzy cognitive mapping approach. *Clim. Chang.* **2014**, *127*, 475–491. [[CrossRef](#)]
20. Adger, W.N.; Huq, S.; Brown, K.; Conway, D.; Hulme, M. Adaptation to climate change in the developing world. *Prog. Dev. Stud.* **2003**, *3*, 179–195. [[CrossRef](#)]
21. Mbaiwa, J.E. Changes on traditional livelihood activities and lifestyles caused by tourism development in the Okavango Delta, Botswana. *Tour. Manag.* **2011**, *32*, 1050–1060. [[CrossRef](#)]
22. Wang, H.; Fu, T.; Zhang, W. The evolution characteristics of China's policy of poverty alleviation by relocation: Based on quantitative analysis of policy texts. *J. CAG* **2017**, *3*, 48–53.
23. Morzaria-Luna, H.N.; Turk-Boyer, P.; Moreno-Baez, M. Social indicators of vulnerability for fishing communities in the Northern Gulf of California, Mexico: Implication for climate change. *Mar. Policy* **2014**, *45*, 182–193. [[CrossRef](#)]