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Do Livelihood Strategies Affect the Livelihood Resilience of Farm Households in Flooded Areas? Evidence From Hubei Province, China

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Hubei Province, located in the middle reaches of the Yangtze River, is a complex area of fragile ecological environment and traditional agricultural production in China. With the further intensification of the impact of global warming, flood disasters have brought a more severe threat to the sustainable development of farmers' livelihoods. This paper therefore examines the livelihood resilience of farmers with different livelihood strategies in the region by constructing a livelihood resilience evaluation system based on three target levels: buffering capacity, Adaptation and restoration, and using a contribution model to identify the main contributing factors affecting the livelihood resilience of fa rmers. The following three conclusions were found: (1). The overall level of livelihood resilience of farmers in flood-affected areas in Hubei Province is not high, and the difference in livelihood resilience indices between farmers with different livelihood strategies is large; (2). Farming-led farmers and part-time balanced farmers can better adapt to external shocks brought about by floods; (3). The main contributing factors affecting the livelihood resilience of various types of farmers have Convergence.

Keywords: livelihood resilience, farmers' livelihood strategies, global warming, flooding impact, farmers' livelihood resilience construction

INTRODUCTION

As global warming intensifies and extreme precipitation events increase, the frequency and intensity of flooding in China is increasing (Hirabayashi et al., 2013; Arnell and Gosling, 2016; Claps, 2017; Bloeschl et al., 2019). Hubei Province, located in the middle reaches of the Yangtze River, has been one of the few provinces in China particularly affected by flooding. Every summer and autumn, when Hubei Province enters the flood season, floods can lead to a lack of security for the lives of local farmers, a reduction in crop production or crop failure, and the resulting adverse effects of health crises, poverty, unemployment, and criminality can seriously threaten the sustainable development of rural areas (De Silva and Kawasaki, 2018; Ma et al., 2021). At the same time, with the rapid transformation of China's economic and social development, farming households have begun to move away from the shackles of the land and choose to go out

to work or operate off-farm, and their choice of livelihood strategies has diversified. This has brought unprecedented challenges to the traditional livelihoods of farmers based on land and labor (Li et al., 2019; Ma et al., 2022). Therefore, how to scientifically integrate the advantages of regional resources, reduce the negative impact of natural disasters on the livelihood development of farming households, and improve the resilience of farming households' livelihoods has become an important issue that needs to be addressed for sustainable livelihood development.

As the most basic economic agents in rural ecosystems, the livelihoods of farmers are most directly affected by floods (Tran et al., 2018; Zhou et al., 2021). Since the 1980s, "livelihood," a new perspective for the study of rural economy and the sustainable utilization of natural resources, has become a hot topic of academic attention (Quandt, 2018; Wang et al., 2021; Yang et al., 2021). Many researchers have developed a multi category livelihood development analysis framework based on Srinivasan and Amartya (1983) feasible ability theory, Among them, the most widely used is the sustainable living hood approach (SLA) proposed by the United Kingdom Department for International Development (DFID) (Saxena et al., 2016; Quandt et al., 2017; Tsolakis et al., 2021). This theoretical framework allows researchers to describe how farmers use their capital holdings and external public services to develop livelihoods in risky environments and changing institutions and organizations. However, traditional livelihood theory has focused mainly on the stock of livelihood capital of farmers and how it is combined, neglecting the ability of farmers to adapt and recover under the impact of external shocks (Shikuku et al., 2017; Reyes-Garcia et al., 2019). As threats from climate extremes intensify, more and more researchers are focusing on the role of resilience thinking in the study of livelihoods (Abdul-Razak and Kruse, 2017).

Resilience theory was first applied by ecologist Holling to study the ability of natural ecosystems to recover to their original state in response to external shocks (Holling, 1973). Livelihood resilience is an extension of the socialization and microcosmization of resilience research objects, referring to the ability of farmers to maintain a basic level of livelihood and recover from disturbances and shocks, both internal and external (Ayeb-Karlsson et al., 2016; Quandt, 2018). This concept combines theoretical thinking on resilience with traditional livelihood research models to provide a more comprehensive and accurate description of how farmers can restore their livelihood status to the ability to maintain their basic functions and structures after external disturbances.

Since Speranza et al. (2014) proposed a quantitative analytical framework for livelihood resilience, consisting of three dimensions: self-organizing capacity, buffering capacity, and learning capacity, academic research on livelihood resilience has moved from the exploration of theoretical frameworks to empirical studies (Milestad and Darnhofer, 2003; Alam et al., 2018; Smith and Frankenberger, 2018). Zhou et al. (2021) measured the livelihood resilience of farm households in earthquake-affected areas of Sichuan Province, China, and found that the livelihood resilience of farm households was mainly based on their ability to prevent and mitigate disasters, and that the stronger the buffer capacity of farm households' livelihoods, the more inclined they were to engage in non-farm activities to earn income; Quandt et al. (2017) studied the livelihood resilience of farming households in Isio County, a semi-arid region of Kenya, and found that farming households that adopt agroforestry may be more resilient in terms of livelihood resilience because farming household livelihood capital can be improved through diversification of farming practices; Stanford et al. (2017) used the principles of the sustainable livelihoods approach combined with a rapid assessment of fisheries sustainability (RAPFISH) methodology to construct a livelihoods resilience assessment framework specifically for small-scale fishers to predict the adaptation of fishers to help prevent and alleviate poverty among this group; Sarker et al. (2020) explored the livelihood resilience of riverine islanders in Bangladesh and found that natural disasters, low income and lack of basic sanitation facilities were the main reasons for the lack of livelihood resilience of vulnerable residents in the area.

Our review of the relevant literature shows that research on livelihood resilience in China started late, and there are few empirical studies on farmers' livelihood resilience in the context of climate disasters in particular. In view of this, this paper attempts to make marginal contributions in the following three areas: (1). An attempt is made to enrich and extend the framework for evaluating the livelihood resilience of farm households proposed by Speranza et al. (2014). This paper adds a target layer of resilience to the livelihood resilience evaluation framework based on previous studies, which is used to measure the ability of farmers to recover from a low level of livelihood status to a high level of livelihood status, which is more relevant to the idea of resilience theory proposed by ecologist Holling. (2). The resilience of livelihoods of farmers in flood-affected areas is studied using a theory of livelihoods resilience that is more appropriate to the Chinese context. This paper uses a sample of farmers in flood-affected areas in Hubei Province to provide evidence from China to study the livelihood resilience of affected farmers and its contribution factors in the context of global warming; (3). By classifying farmers who adopt different types of livelihood strategies, this paper attempts to construct pathways for building the livelihood resilience of different types of farmers, in order to provide theoretical support for government-related policy formulation and self-management of farmers' livelihood resilience in disaster-affected areas.

STUDY AREA AND DATA SOURCE

Study Area

Hubei Province (29°01′53″N-33°6′47″N, 108°21′42″E-116°07′50″E) is located in central China, in the middle reaches of the Yangtze River. The total area of the province is 185,900 km^2, accounting for 1.94% of the total area of China.

Hubei Province is located in the subtropical zone of the northern hemisphere, and most of the province, except for the high mountain areas, has a humid subtropical monsoon climate with an average annual precipitation of 750–1,600 mm, with

individual areas reaching 2,000 mm. and mostly concentrated in summer and autumn, with typical characteristics of rapid drought and flooding. The terrain of the province is roughly surrounded by mountains to the east, west, and north, while the south-central part is the flat and open Jianghan Plain, forming a "quasi-basin" structure with three rising sides and a low center that opens to the south. The Jianghan Plain in the south-central part of the area is a catchment area for the Yangtze River, Hanshui and Hunan's "four waters," and is a place where surface water and groundwater converge and drain. As a result, prolonged heavy rainfall combined coupled with the unique topographical environment gave birth to the geographical pattern of frequent flood disasters in Hubei Province (Wan et al., 2007).

Hubei Province is one of the regions most severely affected by flood disasters in Chinese history. The fragile ecological environment and the industrial structure, which is dominated by agricultural production, have had a great impact on the agricultural management and livelihood development of farmers in the region (Zhou et al., 2019). In particular, the trend of increased and concentrated precipitation in Hubei Province over the past 50 years due to global warming has intensified, with frequent flooding and the geological disasters it causes, further threatening the production and livelihood of farmers. Therefore, it is of practical significance to promote the sustainable development of farmers' livelihood in the region to study the livelihood resilience of farmers in this area and explore the livelihood construction path to improve livelihood resilience.

Data Sources

The data used in this paper come from a household survey conducted by the research team from July to August 2021 in flood-affected areas of Hubei Province. In order to gain a comprehensive understanding of the livelihoods of farmers in Hubei province, the research team selected 39 administrative villages in 12 townships in Honghu and Qichun counties as sample sites based on the characteristics of topography, population distribution and regional livelihoods, with 30–40 households in each village randomly selected for the survey.

The survey was conducted in the form of structured interviews, and the questionnaire included the impact of the natural environment and new economic and social factors on the livelihood recovery capacity of farmers under the influence of floods. A total of 1,100 questionnaires were distributed, and 1,040 valid questionnaires were finally returned, accounting for 99.05% of the total sample, meeting the requirements of reliability and validity of data use. In this paper, after eliminating missing values and outliers of key variables of the data, we finally obtained 993 valid farm household sample data.

LIVELIHOOD RESILIENCE EVALUATION SYSTEM CONSTRUCTION AND VARIABLE SELECTION

At present, the evaluation system of livelihood resilience in academia is still not unified in terms of evaluation dimensions and evaluation indicators (Sina et al., 2019; Ford et al., 2020). Our understanding of livelihood resilience is how economic activity units can more effectively protect their livelihoods and restore their livelihoods more quickly to their ability to maintain their basic functions under adverse environmental impacts. Therefore, the most important issues in livelihood resilience research should lie in the following three aspects: (1). what factors affect the livelihood resilience of farmers in the context of global warming; (2). how farmers can organize themselves to manage and optimize the use of these factors in order to better adapt to the uncertain natural environment and maintain their livelihoods; (3). what factors influence the development of farmers' livelihood resilience as they adapt and maintain their livelihoods. A more widely used framework for livelihood resilience analysis is that proposed by Speranza et al. (2014). This framework achieves a measure of the role of individual behavior and capabilities of farm households in maintaining livelihood stability in the face of persistent external disturbances.

However, it seems that the application of this framework has been hampered by previous theories of sustainable livelihoods, with scholars focusing on the buffering capacity and self-regulation and Adaptation of farmers in the face of external shocks, while neglecting to consider the restoration that can help farmers recover from unfavorable circumstances to a high level of livelihoods (Alam et al., 2018; Jurjonas and Seekamp, 2018; Phuong et al., 2018). Referring to the concept of resilience proposed by ecologist Holling, we believe that the measurement of livelihood resilience should also focus on the restoration of farmers' livelihoods (Yin et al., 2021). Based on this analysis, we constructed a livelihood resilience evaluation index system based on the existing research results in terms of 3 target layers: buffering capacity, Adaptation, and restoration (see **Figure 1**).

Buffer capacity refers to the ability of farm households to maintain the organizational structure and functional attributes of their livelihood systems by converting the livelihood capital they possess in the face of external risk (Speranza et al., 2014). The first issue to be considered in the study of farmers' livelihood resilience is the use of their own livelihood capital to protect themselves against external risks, and the most important way to improve farmers' buffer capacity is to enrich their livelihood capital endowment (Alam et al., 2017; Cooper and Wheeler, 2017). This paper adopts sustainable livelihood capital to reflect buffer capacity: the human capital of farmers is characterized by the educational level of the workforce, health status. Labor is the most important production factor in agricultural production; physical health is often the first to be affected by external shocks (Xu et al., 2019), and health status of family members is also a key piece of human capital. Cultivated land and Convenient transportation are selected to characterize the natural capital of farm households. Land is the most important means of production for farmers, and the greater the ownership of land, the stronger the natural endowment of agricultural production (Meinzen-Dick et al., 2017); the accessibility of transportation plays a crucial role in the expansion of farmers' social network, affecting the quantity and quality of communication between farmers and the outside world. Living area and Durable goods are selected to represent the physical capital of farmers, which can be transformed into financial capital when farmers'

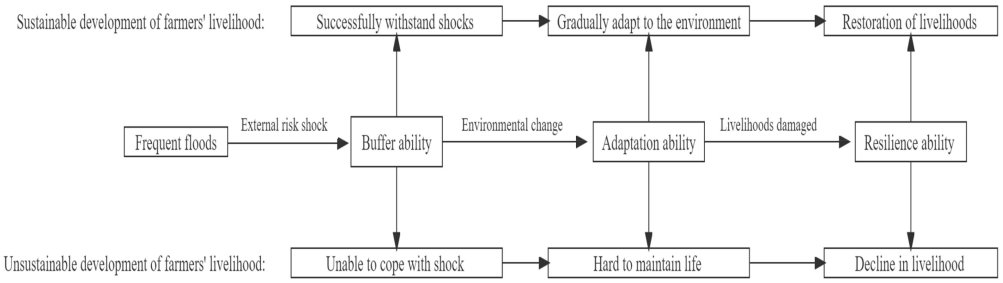

FIGURE 1 | Transmission pathways of the impact of flooding on the livelihood resilience of farm households.

livelihoods suffer from external shocks to improve their buffering capacity (Kong and Castella, 2021). Number of relatives and neighborhoods are selected to represent the social capital of farmers. Chinese villages are a typical society of acquaintances. The more complex the social relations the farmers have, the more opportunities they can seek help (Guan et al., 2018). Income per capita and liabilities are selected to characterize the financial capital of farm households. Financial capital is the most direct manifestation of farm households' buffer capacity, and the possession of financial capital directly determines whether farm households can maintain their basic livelihood status in the face of external shocks (Johanna et al., 2018).

Adaptation refers to the ability of farmers to adapt gradually to their current environment through cognition, learning, and organizational management in order to face external disturbances, and is a potential resilience (Speranza et al., 2014). When sudden external disturbances affect farmers' livelihoods, farmers can use their own buffering capacity to make an initial response, however, the impact of global warming on farmers' livelihoods is comprehensive and long-lasting, especially in the face of longer-term external shocks such as floods, which require farmers to continuously improve their livelihood capital mix to better adapt to external disturbances (Qasim et al., 2016). Agricultural insurance and subjective wellbeing are selected to characterize farmers' cognitive ability. Agricultural insurance, as a means of production risk protection purchased by farmers voluntarily, can help farmers share the losses brought by external shocks, reflecting farmers' subjective initiative in the face of flood shocks (Zeng et al., 2021); subjective wellbeing can be used as a measure of farmers' psychological Subjective wellbeing can be used as a measure of farmers' psychological tolerance, which determines the extent to which farmers can accept external disturbances. Agricultural insurance, as a means of production risk protection purchased by farmers voluntarily, can help farmers share the losses brought by external shocks, reflecting farmers' subjective initiative in the face of flood shocks (Pe'er et al., 2020); subjective wellbeing can be used as a measure of farmers' psychological tolerance, which determines the extent to which farmers can accept disturbances from outside. Information accessibility and cost of education are selected to characterize the learning ability of farmers. As an efficient and low-cost means of social interaction, the Internet can help farmers control market information in a more timely and accurate manner, and adjust their livelihood strategies to cope with the impact of environmental changes in the shortest possible time, which is in line with Milestad and Darnhofer (2003) definition of farmers' adaptation; although the cost of household investment in education and training will adversely affect the livelihood recovery ability of farmers in the short term, as a forward-looking investment with higher returns, it can reflect the learning ability of farmers, which is also related to livelihood recovery ability (Sujakhu et al., 2018). Ratio of party members and government staff were selected to characterize the organizational ability of farm households, and the increase in adaptation was also related to the extent to which farm households were linked to organizations such as government and community (Cofre-Bravo et al., 2019). Due to the specific nature of China's grassroots political system (Zhang et al., 2019), the greater the number of peasant households who are members of the Party and the greater the number of relatives in the family who work for the government, the closer the peasant households are to the grassroots organizations of the local government.

Restoration is one of the most central aspects of livelihood resilience, as farmers use both external support and internal drivers to counteract persistent external disturbances and in the process recover from low to high levels of livelihood status (Ravera et al., 2016). Government help, production support, and transferable income are selected to characterize the exogenous power of farmers. When farmers cope with natural disasters such as floods, their individual power is often too small, so government help is needed to help them recover from external shocks (Yang et al., 2021); the transfer income from the government or friends and relatives is also an important component of household income, especially in times of hardship, which can be regarded as a financial capital with obvious support (Ravera et al., 2016). Income diversity index, proportion of non-farm labor, total workforce are selected to characterize the endogenous power of farm households. With the household income diversification indicator representing the diversification of livelihood strategies adopted by farmers, implying that when farmers are affected by floods and are unable to farm, they can enrich their livelihood capital through other production methods (Zhu et al., 2018). The higher the number of farm households in off-farm employment, the more experience they have in other forms of production, which, like the level of education of the farm labor force, are both human capital accumulation. The stronger this endogenous

drive is, the greater the likelihood that farmers will recover their livelihoods or even break out of the constraints of their previous livelihoods to gain greater development prospects.

CALCULATION METHODS AND DESCRIPTIVE STATISTICS FOR LIVELIHOOD RESILIENCE

Because of the diversity of external risk shocks to which farmers are exposed, the weight of each target layer that constitutes livelihood resilience is also difficult to analyze quantitatively using technical methods. Based on this, we first used the expert scoring method to determine the weights of the three attributes of buffering capacity, adaptation and restoration in the livelihood resilience of farmers. The specific process was to solicit the opinions of relevant experts by anonymously, and then to count, process, analyze, and summarize the opinions of experts, and finally determine the weight of each target layer after several rounds of opinion solicitation, feedback, and adjustment (Westerveld et al., 2021). The entropy value method was also used to measure the weights of the specific indicators that constitute the livelihood resilience (Hainmueller, 2012; Xu et al., 2019). The basic model is as follows:

$$Z = \begin{bmatrix} X_{11} & \cdots & X_{1m} \\ \vdots & & \vdots \\ X_{n1} & \cdots & X_{nm} \end{bmatrix} \tag{1}$$

In Equation (1), construct a judgment matrix Z of m assessment indicators for a sample of n.

$$s_{ij} = \frac{X_{ij} - X_{i\min}}{X_{i\max} - X_{i\min}} \tag{2}$$

In Equation (2), X_{ij} is the actual value of the ith evaluation object on the jth evaluation indicator, $X_{i\min}$ is the minimum value of the statistical data on the ith evaluation object, $X_{i\max}$ is the maximum value of the statistical data on the ith evaluation object and s_{ij} is the standard value of the ith evaluation object on the jth evaluation indicator.

$$S = (r_{ij})_{i\times j} \tag{3}$$

In Equation (3), the new judgment matrix $S$is obtained after dimensionless processing of the data using the extreme value method.

$$f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} \tag{4}$$

In Equation (4), f_{ij} is the characteristic weight of the ith evaluation object on the jth evaluation indicator.

$$E_j = -\frac{1}{\ln(\sum_{j=1}^{n} \ln f_{ij})} \tag{5}$$

In Equation (5), according to the definition of entropy value, the entropy value for n sample of m assessment indicators is E_j. To make sense of $\ln f_{ij}$, assume that $f_{ij} = 0$ when $f_{ij} \ln f_{ij} = 0$.

$$W_j = \frac{1 - E_j}{m - \sum_{j=1}^{m} E_j} \tag{6}$$

In Equation (6), W_j is the weighting factor of the jth evaluation indicator and satisfies $\sum_{j=1}^{m} W_j$ (see **Table 1**).

$$L_i = (B_i + A_i + R_i) \times W \tag{7}$$

Calculated by weighted average, with the ith evaluation object buffering capacity B_i; adaptation A_i; and restoration R_i. W is the weight of each target layer.

RESULTS

Livelihood Resilience Analysis of Farm Households

As can be seen from **Table 2**, the livelihood resilience index of farmers in flood-affected areas in Hubei Province is low, at 0.182, with Qichun County, a predominantly mountainous area, having a livelihood resilience index of 0.212 and Honghu City, a predominantly plain terrain, having a livelihood resilience index of 0.174. The main reason for the difference in livelihood resilience between the two areas is that farmers living in mountainous areas have more severe living conditions and are more likely to be affected by floods, so they have a stronger awareness of flood prevention in this type of farmers. In terms of each target stratum, the buffering, adaptation and resilience indices of Qichun County farmers are higher than those of Honghu City farmers, indicating that mountain farmers have a better overall ability to cope with flood impacts than those in the plain areas.

Classification of Farmers' Types and Calculation Results of Livelihood Resilience Index

As China's urbanization process continues, a large number of rural workers are choosing to leave the land to seek better employment opportunities and higher labor income in the cities, and the livelihood strategy choices of farming households in flood-affected areas of Hubei are also showing a trend toward diversification (Zhan, 2017; Lu et al., 2019). Differences in livelihood strategy choices inevitably lead to different allocations of livelihood capital, which in turn has a heterogeneous impact on the livelihood resilience of farm households. On the other hand, although the diversification of farmers' livelihood strategy choices has enriched their income channels, there is still the phenomenon of households with different livelihood strategy types being dominated by one income source due to the limited quantity and quality of labor at their disposal (Frelat et al., 2016). Therefore, using a particular source of income accounting for 60% of total household income and above as a classification criterion, farming households are divided into 5 types: (1). New agriculture-led

TABLE 1 | Livelihood resilience evaluation indicator system.

Target layer	Weight	Dimension	Index	Mean	Weight	Interpretation and assignment instructions
Buffer capacity	0.3	Human capital	A1: Educational level of the workforce	3.641	0.004	Continuous variable, average years of education of family labor force.
			A2: Health status	3.186	0.004	Continuous variable, mean of self-assessed health status of household members.
		Natural capital	A3: Cultivated land	1.533	0.056	Continuous variable, ratio of household arable land area to household size.
			A4: Convenient transportation	0.836	0.014	Whether the home is next to a motor vehicle driveway. Yes = 1; No = 0.
		Material capital	A5: Living area	52.736	0.014	Continuous variable, the ratio of household housing area to household size.
			A6: Durable goods	1.336	0.128	Continuous variable, the value of household durable goods including agricultural production machinery.
		Social capital	A7: Number of relatives	7.458	0.030	Continuous variable, the number of kin families with close ties.
			A8: Neighborhoods	1.600	0.008	Five point scale method. Evaluation of the trust relationship between neighbors.
		Finacial capital	A9: Income per capita	10.899	0.001	Continuous variable, ratio of total household income to household size.
			A10: Liabilities	2.688	0.0683	Continuous variable, logarithm of household debt amount.
Adaptation	0.3	Cognitive	B1: Agricultural insurance	1.626	0.016	Whether the farmer has agricultural insurance. Yes = 1; No = 0.
			B2: Subjective wellbeing	0.178	0.124	Continuous variable, mean of self-rated happiness of household members.
		Learning	B3: Information accessibility	0.342	0.077	Does the household use the internet to access useful agricultural information. Yes = 1; No = 0.
			B4: Cost of education	4.834	0.046	Continuous variable, logarithm of the total amount households invest in education.
		Organization	B5: Ratio of party members	0.225	0.107	Continuous variable, the ratio of the number of members of the family who joined the Chinese Communist Party to the total family population.
			B6: Government staff	0.227	0.1067	Whether the family has relatives working in government departments. Yes = 1; No = 0.
Restoration	0.4	Exogenous power	C1: Government help	1.685	0.006	Continuous variable, rating of household satisfaction with government support efforts.
			C2: Production Support	0.062	0.199	Whether the farmer can receive support from the village enterprise when conducting agricultural production. Yes = 1; No = 0
			C3: Transferable income	6.787	0.010	Continuous variable, logarithm of total income received by the household from the government or from relatives and friends.
		Endogenous power	C4: Income diversity index	2.320	0.007	Continuous variable, the number of different types of income in the total household income.
			C5: Proportion of non-farm labor	0.376	0.023	Continuous variable, the ratio of the number of household non-agricultural labor force to the total number of labor force.

type. This type of farmers take agricultural specialization as the main production method and special agricultural production as the main source of income. (2). Farming-led. A group of farmers whose main source of income is traditional rainfed dry farming or farming; (3). Labor-led. This refers to the fact that most of the labor force of farmers chooses to leave the primary industry and devote themselves to the secondary and tertiary industries with higher income, and the family income is mainly wage income; (4). Part-time balanced type. This group of farmers has a large amount of household labor at their disposal, and they earn business income from agricultural production and wage income from other sources; (5). Subsidy-dependent. This group of farmers is usually more elderly or have low working capacity due to illness or disability, and rely on state assistance or pensions for their income.

There are significant differences between farming households in terms of the number of household laborers, household income diversity index and government support. Therefore, by analyzing the internal differences of different types of farmers' livelihood resilience and their composition, we can put forward corresponding livelihood resilience-building paths for various types of farmers, so as to improve the ability of farmers to deal with the external impact caused by global warming. At the same time, in order to ensure that there are significant differences between the groups, we use the one-way variance

TABLE 2 | Livelihood resilience index.

Region	Buffer capacity	Adaptation	Restoration	Livelihood resilience
Qichun	0.233	0.261	0.160	0.212
Honghu	0.116	0.259	0.159	0.174
Total sample	0.136	0.256	0.160	0.182

TABLE 3 | Livelihood resilience index for each type of farm household and ANOVE analysis.

Farmer type	Buffer capacity	Adaptation	Restoration	Livelihood resilience	ANOVE Analysis	
New agricultural-led	0.206	0.381	0.115	0.222	*F*-value	*P*-value
Farming-led	0.185	0.293	0.106	0.186		
Labor-led	0.163	0.260	0.169	0.195	12.749	0.000
Part-time balanced	0.181	0.315	0.152	0.210		
Subsidy-dependent	0.195	0.155	0.139	0.147		

TABLE 4 | Contribution of indicators for each target tier of farm household livelihood resilience.

Farmer type		Buffer capacity			Adaptation			Restoration		
New agricultural-led	Contribution factor	A4	A10	A1	B3	B4	B1	C4	C3	C1
	Contribution	0.930	0.647	0.623	0.561	0.545	0.439	0.662	0.611	0.360
Farming-led	Contribution factor	A4	A10	A9	B3	B4	B1	C4	C1	C3
	Contribution	0.922	0.756	0.732	0.481	0.398	0.325	0.555	0.554	0.527
Labor-led	Contribution factor	A10	A8	A2	B4	B3	B2	C4	C3	C5
	Contribution	0.812	0.743	0.525	0.436	0.336	0.317	0.787	0.570	0.438
Part-time balanced	Contribution factor	A10	A9	A2	B3	B4	B2	C4	C3	C5
	Contribution	0.804	0.744	0.532	0.475	0.455	0.346	0.870	0.542	0.352

score method (ANOVE) to analyze the differences of livelihood resilience of different types of farmers. The results show that there are significant differences in livelihood restoration capacity among different types of farmers ($P = 0 < 0.05$), as shown in **Table 3**.

In terms of livelihood resilience, the farmer with the highest index of livelihood resilience is the new agriculture-led type (0.222); the lowest index is the subsidy-dependent type (0.147). The new type of agriculture-led farmers are in the lead in terms of buffering and adaptability, which may be because such farmers have accumulated rich experience in dealing with various external shocks caused by global warming during their long-term agricultural production. On the other hand, the "rural revitalization" strategy implemented by the Chinese government in recent years has greatly increased the policy support for farmers' production and livelihood, especially when the agricultural production projects they are engaged in are damaged by floods, farmers can Obtain a substantial amount of compensation from government agencies or state-run agricultural insurance companies. Therefore, farmers of this type are more likely to gain the comparative advantage of livelihood recovery from government assistance. The subsidy-dependent farmers have the lowest livelihood resilience index because they have insufficient household labor, which leads them to lack the human capital to cope with natural risk shocks including floods.

In terms of buffer capacity, the farm household type with the highest livelihood buffer capacity index was the new agriculture-led type (0.206); the lowest index was the labor-led type (0.163). The subsidy-dependent farming households that lacked labor capacity achieved a higher score (0.195) in this dimension, which may be somewhat counterintuitive. However, from the perspective of policy implementation, the Chinese government has increased its financial support to rural areas in the "poverty alleviation" implemented in 2015. In particular, farmers who are widowed, have a disabled family member or are suffering from a serious illness receive a stable monthly payment from the government, and the livelihood of these farmers is covered by the government. On the contrary, labor-led households do not have a comparative advantage in terms of policy support, resulting in a low score in this dimension.

In terms of restoration, the farm household with the highest livelihood restoration index was the labor-led type (0.169); the lowest index was the farm-led type (0.106). This may be due to the fact that the income impact of floods on labor-led households is small and they can recover quickly from the floods. On the contrary, farm-led households have a natural vulnerability as their livelihoods are mainly based on traditional farming. Therefore, they are less able to recover from the adverse environment.

Analysis of Factors Contributing to Livelihood Resilience of Farm Households

The study on the livelihood resilience of farmers not only aims to assess the livelihood status of different types of farmers, but more importantly, to clarify the dominant contributing factors affecting the livelihood resilience of farmers, so that policies and recommendations can be made in a targeted manner (Xu et al., 2018; Guo et al., 2019; Wójcik et al., 2019). Therefore, this paper applies a contribution model to calculate the contribution of each indicator to livelihood resilience by dimension, and selects the top four indicators in terms of cumulative contribution as the dominant contributors (see **Table 3**).

$$C_j = p_{ij}g_j / \sum_{j=1}^{m} p_{ij}g_j \times 100\% \quad (8)$$

In Equation (8), C_j is the degree of contribution of the jth evaluation indicator to the target, p_{ij} is the degree of affiliation

of the indicator to the target, and g_i is the degree of influence role of the jth evaluation indicator on the target (see **Table 4**).

In terms of buffering capacity, the main contributors to the livelihood resilience of the five categories of farm households are concentrated in farm households' financial capital. The losses caused by floods to farmers are undoubtedly huge, and many farmers even sell valuable household assets to maintain the stability of household livelihood status, and the negative marginal effect of household liabilities (A10) is stronger when farmers' livelihood status is unstable.

In terms of adaptation, the main contributing factors to the livelihood resilience of the five categories of farmers were focused on cognitive and learning. Agricultural insurance (B1), as an underwriting protection for agricultural production risk, can help farmers recover agricultural losses caused by floods to a certain extent, and the stronger the willingness of farmers to purchase agricultural insurance, the stronger the subjective initiative of farmers to resist risks. At the same time, rural China is a typical "human society," and farmers have advantages in terms of information access and policy knowledge, which makes them better able to adapt to changes in the external environment. The cost of education (B4), as a long-term investment, can help farmers improve the quality of their family members and enhance their competitiveness in different environments.

In terms of resilience, the main contributing factors shared by the five types of farm households are transferable income (C3) and household income diversity index (C4). With the increase of production and livelihood subsidies by the Chinese government, transferable income (C3), as an important source of income for farm households, can be directly transformed into financial capital of farm households and improve their livelihood resilience. When the impact of flooding exceeds the capacity of farmers, they have to give up their agricultural production and earn income through other channels to maintain their livelihoods. The higher the household income diversity index (C4), the richer the income sources of farmers and the stronger the resilience of farmers.

DISCUSSION AND LIVELIHOODS RESILIENCE BUILDING PATHWAYS

Conclusion of the Study

Some scholars have systematically introduced the theoretical content and scientific value of the resilience of farmers' livelihoods, but since the concept of resilience was introduced into the field of farm livelihoods from the discipline of natural ecology, further research on the resilience of farmers' livelihoods needs to be further explored (Alam et al., 2018; Quandt, 2018; Smith and Frankenberger, 2018; Wang et al., 2021; Yang et al., 2021). Based on the research results of previous scholars, this paper constructs an evaluation system of farmers' livelihood resilience consisting of three target layers: buffering, adaptation and restoration, in the context of the further intensification of the threat to farmers' livelihoods caused by floods in Hubei Province as a result of global warming, by combining the links between external disturbances, government management and farmers' livelihood strategies. Through a combination of theoretical analysis pathways and empirical research, the following conclusions were drawn.

The overall level of livelihood recovery capacity of farming households in flood-affected areas in Hubei Province is not high. The overall livelihood restoration ability of farmers in Hubei Province is low, and the topographic factors have great differences in the livelihood resilience of farm households. Among them, the livelihood resilience index capacity of farm households in Qichun County, which is mainly mountainous area, is 0.212, and the livelihood resilience index capacity of farm households in Honghu City, which is mainly plain terrain, is 0.174.

New agriculture-led and part-time balanced households are better able to adapt to external shocks caused by floods. The analysis of the livelihood resilience indices of each type of farmers shows that the new agriculture-led and part-time balanced farmers have comparative advantages in the total index as well as several target level indices. Therefore, these two livelihood strategies should be the main direction for the livelihood development and transformation of the remaining types of farm households, especially combining with regional characteristics, giving play to the role of high-quality agricultural production areas, and gradually transforming and developing into new agriculture-oriented farm households with special industries, which has important practical significance for promoting the sustainable development of farm households' livelihoods.

The main contributing factors affecting the livelihood resilience of each type of farm households were mainly focused on household income. Looking at the three target layers separately, the main contributing factors of livelihood buffer capacity were concentrated in income per capita (A9), liabilities (A10); the main contributing factors of livelihood adaptation were concentrated in agricultural insurance (B1), cost of education (B4); the main contributing factors of livelihood restoration were concentrated in transfer income (C3), household income diversity index (C4). These factors have direct or indirect relationships with farm household income.

Optimization Strategies for Farmers' Livelihood Resilience

From the results, the livelihood resilience index of Hubei farmers is low and the livelihood sustainability of farmers is poor. Starting from each subject of regional economic development, we put forward the following three policy suggestions. First, regional governments should actively play the role of policy regulation and guidance. Before floods occur, the government should establish a sound disaster warning mechanism and encourage farmers to take pre-disaster precautions in the form of government subsidies or other incentives; second, in terms of livelihood employment, the government should focus on the development of the regional economy and strive to provide farmers with more suitable employment opportunities and financial support for agricultural production. Third, Third, farmers should also pay

attention to the development of improving labor skills and their own quality. For farmers with insufficient family labor capacity, regional governments should also appropriately improve the coverage and support of rural inclusive policies according to the development of regional economy, as well as gradually improve the construction of mechanisms to consolidate the effectiveness of "poverty eradication" and rural pension mechanisms, so as to actively play the role of the government in underwriting the livelihood of vulnerable farmers.

Identifying regional resource advantages and enriching livelihood strategy options for farmers. Regional economic development agents should promote the development of new types of professional farming households based on the advantages of regional resources. As the livelihood resilience index is higher for farming-led and part-time balanced farmers among all types of farmers, the government should encourage farmers with labor conditions to take the initiative to choose livelihood strategies with higher comparative returns and provide the necessary policy support for farmers to change their livelihood strategies. For example, agricultural insurance, micro-credit for agricultural production, infrastructure development, etc. At the same time, subsidy-dependent farmers should make use of the labor force in the household that is still capable of production to develop a garden economy or develop elderly agriculture based on improved agricultural mechanization and social services in order to increase their income.

Building a livelihood restoration capacity guarantee system for farmers, mainly through industrial and financial collaboration and supplemented by policy protection. The proportion of inputs represented by capital in modern agricultural production is gradually increasing, and the financial burden of farmers in carrying out agricultural production is becoming a major source of debt for their households. The government should provide greater support to farmers who are able to repay their loans in terms of the period of use, the amount of the loan and the loan approval process. At the same time, the government should work together with insurance companies to develop a better agricultural insurance system to enhance the ability of farmers to withstand external risk shocks. On the other hand, rural grassroots organizations should also implement the various disaster prevention and relief policies formulated by higher-level organizations and actively guide local farmers to choose more appropriate livelihood strategies. By building a livelihood resilience system based on industrial and financial collaboration, supplemented by policy protection, the main problems that contribute to the low livelihood recovery capacity of farmers can be addressed.

SHORTCOMINGS OF THE RESEARCH DESIGN AND FUTURE RESEARCH DIRECTIONS

Due to the limitation of the study area and the different stages, attributes of rural development in various regions, this may lead to differences in the availability of individual livelihood indicators and the level of policy support available to farmers, resulting in differences in the selection of alternative indicators for the evaluation of the livelihood resilience of farmers in different regions. To address this shortcoming, the next research directions of the group are: firstly, to optimize the scope of application of the indicators that make up the livelihood resilience evaluation system, and secondly, to develop various livelihood resilience evaluation systems for farmers under the extreme climate impacts caused by global warming.

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/s.

AUTHOR CONTRIBUTIONS

XL and CZ were primarily responsible for writing the main body of the manuscript. JS provided the original data used in this manuscript. XL and ZQ provided the results of the empirical analysis for the research in this manuscript. WL provided all the tables used in this manuscript. WW made significant contributions to improve the manuscript. All authors contributed to the article and approved the submitted version.

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