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Evaluation and influencing factors of ecological resilience in tourism villages from farmers' perspectives: a case study of Chinese minority settlement areas

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Rural social-ecological systems have been significantly impacted by the development of rural tourism, creating substantial challenges for the synergistic development of rural ecological restoration and agricultural workers' household livelihoods. In alignment with the United Nations Decade on Ecosystem Restoration action plan, it is crucial to understand the ecological resilience of tourism villages from the perspective of farmers to achieve sustainable development. Questionnaires and semi-structured interviews were conducted in this study to gather livelihood data from farmers in tourism villages in Xiangxi, China, a region primarily inhabited by ethnic minorities. A measurement index system for the ecological resilience of rural tourism was constructed based on the three dimensions: pressure, state, and response. A comprehensive index method was employed for quantitative evaluation, and influencing factors were analyzed using an obstacle model. The results show that farmers' livelihoods can be divided into four types: tourism-led, labor-led, agriculture-led, and part-time tourism-based. Their ecological resilience indices are 0.4516, 0.4177, 0.4001, and 0.4590, respectively, representing an overall intermediate level. There are differences in various indices for different livelihood types, with the highest stress index observed in labor-led farmers (0.1655), the highest state index in agriculture-led farming households (0.1585), and the highest response index in tourism-led farming households (0.1766). Common obstacles to the ecological resilience of farmers and their villages include the number of family members engaged in tourism work, the area of forest land, and the farmers' understanding of ecological policies affecting them. Additionally, core family members' education levels and the area of homesteads emerged as important obstacle factors. Based on these research findings, recommendations are proposed to enhance the ecological resilience of rural farmer households in the tourism villages of ethnic minority areas. The aim is to provide valuable case studies for promoting the sustainable development of rural tourism in underdeveloped regions worldwide.

KEYWORDS

tourism villages, farmers' household livelihoods, ecological resilience, obstacle factors, Xiangxi region, China

1 Introduction

Human activities have inflicted damage on the natural ecological environment, prompting global attention towards ecological protection and restoration. The United Nations Environment Programmer (UNEP) and the Food and Agriculture Organization of the United Nations (FAO) co-lead the United Nations Decade on Ecosystem Restoration Programmer, which aligns with the Sustainable Development Goals (SDGs) in the objective of restoring ecosystems to promote social transformation (Linster, 2003).

Rural areas, as the fundamental form of human settlement and the world's basic societal unit, constitute a vital component of the global ecological environment. Safe-guarding rural ecologies and advancing rural ecological governance are essential pre-requisites for achieving sustainable development. The world's accelerating urbanization and globalization processes have propelled rural tourism as a means of enhancing agricultural workers' livelihoods and providing impetus for rural economic development. In ethnic areas, rural tourism is an economic form based on natural landscape and historical and cultural resources, which is an important and effective way to inherit ethnic culture and realize rural revitalization (Rosalina et al., 2021). However, the unchecked destruction of rural social-ecological systems during tourism development cannot be overlooked. This phenomenon significantly hampers the economic progress of tourism villages and the improvement of farmers' household livelihoods (Diaz-Sarachaga, 2020).

Rural tourism yields both positive and negative feedback effects on rural social-ecological systems, which has garnered increasing scholarly attention from researchers examining the impact of tourism. On the positive side, rural tourism can enhance the rural ecological environment through improvements in the production environment, living environment, and environmental governance (Ingrassia et al., 2023). Factors such as population, capital, land, and policy play pivotal roles in transforming and developing the rural tourism ecological environment (Cheng et al., 2022). However, negative tourism-related effects such as resource wastage (Rodriguez-Perez et al., 2022), soil and water pollution (Mihai et al., 2022), and the destruction of ecosystem services (Assiouras et al., 2022) adversely affect rural ecosystems.

Rural tourism is also associated with the development of rural industries (Andersson, 2021), up-grades to infrastructure (Zhu et al., 2022), and the creation of diverse employment opportunities, thereby enhancing the livelihoods of agricultural workers and their households (Hussain et al., 2019; Lin, 2020). Nevertheless, uncertain risks, homogenized competition, and predicaments related to low participation in the tourism sector (Kwaramba et al., 2012; Randelli et al., 2014) can be problematic. Considering these complex risks and disturbances, many scholars have argued that resilience is a crucial means of improving the environment and fostering the sustainable development of human societies (Ferguson and Wollersheim, 2023). Consequently, research on the ecological resilience of tourism villages (or simply, "tourism villages") from the farmer's perspective holds significant practical importance. This approach aims to identify ways to cultivate villages' adaptability to disturbances and, in turn, enhance farmers' household livelihoods.

In 1973, ecologist Holling (1973) introduced the concept of resilience to the field of ecology, defining it as the ability of an ecosystem to maintain its structure and functions in the presence of external disturbances. As the contradiction between human society and the natural environment becomes increasingly prominent, resilience has evolved into an important criterion for measuring the sustainability of social-ecological systems has expanded into the realm of sociology (Gunderson and Holling, 2004). According to Walker et al. (2004), resilience denotes the capacity of social-ecological systems to revert to their initial state while continually adapting in response to external disturbances.

Research on ecological resilience at the micro-rural is gradually being prioritized. Current research on rural resilience mainly centers on frameworks for resilience analysis, resilience-level assessments, and investigations of the factors influencing resilience (Calgaro et al., 2014; Li et al., 2022; Huang et al., 2017). Scholars commonly collect data through questionnaire surveys or in-depth interviews (Li et al., 2022; Zhong et al., 2022), constructing multidimensional indicator systems based on their specific subject areas or research perspectives. For example, some scholars have assessed comprehensive rural resilience based on production, ecology, society, system, and economy as the core (Wang et al., 2021), while others have constructed frameworks for assessing rural system resilience with resources, form, and function as the core based on the rural system resilience (RRS) mechanism (Li et al., 2022). Some scholars have established indicator systems for rural resilience based on ecological sub-systems, economic sub-systems, social sub-systems, cultural sub-systems, and governmental sub-systems (Wang et al., 2023). However, there is a lack of consensus regarding the most effective assessment framework for rural resilience.

Various quantitative measurement methods, such as the entropy weight method (Wang et al., 2021), Topsis method (Qin et al., 2023), and comprehensive index method (Wang et al., 2023) have been employed for assessing rural resilience. Analytical tools like the obstacle model (Qin et al., 2023), the structural equation model (Zhao et al., 2023), regression analysis (Tomás et al., 2020), and the geographic detector (Wang et al., 2023) have also been widely used in exploring the factors that influence rural resilience (Ingrassia et al., 2023; Berkes and Ross, 2013; Espiner et al., 2017). Among them, the entropy weight method can reduce the influence of subjective factors, so the calculation results are more reliable. Composite index method can reflect the overall direction and degree of change of complex phenomena, and can quantitatively illustrate the actual effect of phenomenon change. Obstacle degree model can find out the key factors limiting things, and clarify the degree of influence of key constraints. Existing research indicates that issues like land degradation can adversely impact rural societies, economies, and natural environments, leading to a reduction in rural resilience (Baird, 2018). Safeguarding the ecosystem has been identified as the key to improving the resilience of farmers to external disturbances and achieving high-quality rural development (He et al., 2017). Socio-economic diversity is further recognized as a promoter of high-quality rural development (Chen et al., 2017), while local culture (Chiang et al., 2014), carbon emissions (Sena et al., 2022), and government management (Henderson et al., 2020) also significantly impact on rural resilience. Despite extensive studies on influencing factors and cultivation paths for rural resilience, there is a notable gap in targeted studies on rural tourism, which is a significant contemporary disturbance factor. Few studies have vividly or

subtly characterized the current level of ecological resilience in tourism villages.

Rural tourism has a dual impact on local rural ecosystems and on the livelihoods of rural households (Cheng et al., 2022; Ingrassia et al., 2023). While the influence of rural tourism on rural social ecological systems is widely recognized, there has been little research attention given to the manner in which famers respond to rural tourism and the consequential effects of farmers' behavior on the rural social-ecological system. Consequently, exploring the ecological resilience of tourism rural areas from the perspective of farmers holds significant theoretical and practical importance. In this study, we adopted micro-farming households as a research unit, incorporating the resilience theory, sustainable livelihoods theory, and farmers' behavior theory into our analysis (Wu et al., 2023). Utilizing the pressure-state-response (PSR) analysis framework, we comprehensively structured an analytical basis for evaluating the ecological resilience of tourism villages (Zhang et al., 2023). This evaluation spanned three dimensions: pressure, state, and response. By categorizing farmers' households based on their livelihood types and employing the comprehensive index method, along with the obstacle degree model, we explored the differentiation characteristics and obstacle factors of farmers' ecological resilience amidst the impacts of tourism-related disturbances to their environment. Emphasizing the role of farmers' subjective initiative in rural ecology, we conducted targeted research delving into the nuanced aspects of ecological resilience in the countryside. This work not only broadens the theoretical understanding of rural resilience, but also enriches the perspectives within rural resilience research. We also offer case studies that may serve as a valuable reference in the sustainable development of tourism villages in other underdeveloped ethnic regions of the world.

2 Theoretical framework and Index system

2.1 Theoretical framework

The tourism village's social-ecological system is a complex entity formed by interconnections among people, industry, and land. The system is diverse, dynamic, and unstable, among other notable characteristics (Becken, 2013). As pivotal actors in rural social-ecological systems, farmers play a crucial role in the sustainable development of tourism villages. Tourism villages are affected by tourism development as well as the activities of agricultural workers in sustaining their livelihoods, which together continuously restructure resources, environments, and production relations within these villages (Wang et al., 2021). Ecological resilience, as an intrinsic property of the social-ecological system in tourism villages, enables adaptation of functional structures, leading villages to return to a new state of stability after external disturbances.

The PSR framework is widely utilized in social-ecological research. It is a practical approach to elucidating interactions among human behaviors, the environment, and resources (Chen et al., 2022). This framework may also be utilized to gain systematic insights for ecological resilience research. In this study, pressure (P) characterizes the disturbance of rural ecosystems by the livelihood-related activities of farmers' households, which specifically manifests in disturbances on villages caused by population pressure, environmental pressure, and land pressure. State (S) signifies the horizontal state of farmers' household livelihood systems after the villages have endured disturbances, encompassing social resources, production land, and living standards. Response (R) refers to the ability of farmers to respond and adapt to external disturbances, ultimately improving the rural social-ecological system. The ecological resilience of tourism villages from the perspective of farmers is the result of combined internal and external disturbances at work in the system. The development of these villages is a dynamic evolutionary process.

Firstly, through various livelihood-related activities, farmers' households obtain the resources required for survival and development from the rural social-ecological system (Wu et al., 2022). While at the same time exerting pressure on the rural population, environment, and land. Secondly, tourism-related disturbances induce changes in the organization and function of the rural social-ecological system, impacting the livelihoods of farmers and their households through positive and negative feedback. This alters their social resources, production land, and living standards. Finally, farmers' households enhance their risk resilience and information acquisition capacity through livelihood-related responses, transforming their livelihoods in alignment with the tourism sector, gaining ecological awareness, and managing livelihood-related behaviors in other adaptive ways.

These insights can be applied to the practical management of rural social-ecological systems. The above analysis was utilized to construct a framework for evaluating the ecological resilience of tourism villages from the perspective of farmers (Figure 1).

2.2 Index system

Based on the above analytical framework (Figure 1), referring to the existing research results of other scholars, and combining the farmers livelihood theory (Wu et al., 2021), resilience theory (Dong et al., 2022), farmers behavior theory (Sok et al., 2021), and the nuances of the case-study villages, the ecological resilience evaluation index system of the tourist villages from the farmers' perspective was constructed. This comprehensive system includes 18 indexes and three dimensional layers: a pressure layer, state layer, and response layer (Table 1). In this study, rural ecological resilience is understood as a composite of three dimensions: stress index, state index and response index. And the pressure index, state index and response index can be characterized by six indicators. The entropy method was applied to calculate the weights of each index (Qin et al., 2023), facilitating the interpretation of each factor and index layer. The composite index method was used to calculate the level of ecological resilience.

The pressure index layer is a subjective manifestation of farmers' disturbances within rural ecosystems, reflecting the extent of disruption to the social-ecological system of tourism villages caused by farmers' livelihood-related activities (Becken, 2013). A higher pressure index indicates more pronounced disturbance to the rural ecology. There is a total of six indices in this layer. Among them, number of family surplus laborers C_1 is an important indicator of population pressure; greater household surplus labor

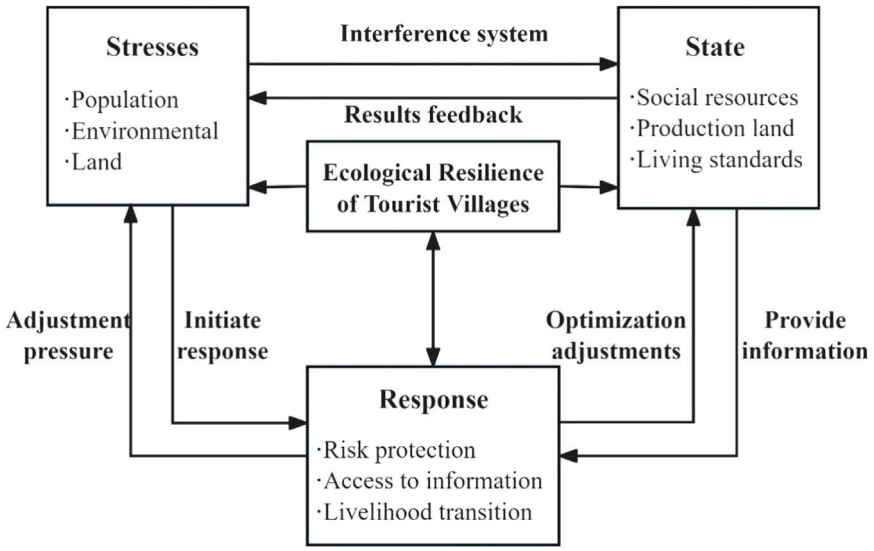

FIGURE 1
PSR relationship of tourism-village ecological resilience from farmers' perspective (Modified from Linster's PSR analysis framework).

indicates increased resource consumption. Monthly energy costs C_2, transportation mode C_5, and homestead area C_6 reflect the demand for rural resources and the degree of utilization of rural households. Land pesticide costs C_3 and fertilizer costs C_4 specifically express the pressure on the rural environment exerted by farmers' livelihood-related activities. Higher pesticide and fertilizer costs correlate with stronger disturbance to the rural ecological environmental.

The state index layer represents the objective state level of the rural social-ecological system after disturbances. A higher state index indicates a higher livelihood level for farmers. This layer encompasses six indices. Among them, the type of access to subsidies C_7 directly reflects the social resources available to farm households. Agricultural acreage C_8 and family forest land area C_9 are direct indicators of the land used for production; annual *per capita* income C_{10}, education level of core family members C_{11}, and total household fixed assets C_{12} are indicators of the household's standard of living.

The response index layer gauges farmers' abilities to respond to tourism-related disturbances, enabling behavioral adjustments to improve the rural social-ecological system (Xiao et al., 2023). A higher response index reflects a stronger ability of farmers to adapt. Once more, there are six indices in this layer. Increasing annual family education expense C_{13} is a particularly effective measure of farmers' abilities to withstand risks when faced with external disturbances. Monthly mobile phone communication costs C_{15} and the type of eco-policy understanding C_{16} form the basis for strengthening the farmers' abilities to obtain information, helping them to improve ecological awareness and adapt their livelihood-related behaviors. The number of migrant workers C_{14}, the number of family members engaged in tourism work C_{17}, and the support for rural tourism development C_{18} can promote the ecological resilience of the farming house-holds. Resilience enhancement serves as a crucial pathway toward sustainable development in this regard.

3 Methodology

3.1 Study area

The Xiangxi region is located in the western part of Hunan Province, China, encompassing the Xiangxi Autonomous Prefecture, Huaihua City, and Zhangjiajie City within its administrative areas. Spanning 78,700 km^2, the region has a minority population accounting for 80.5% of its inhabitants. Renowned as one of China's most culturally rich ethnic regions, Xiangxi is home to 395 national level traditional villages showcasing a profound ethnic cultural heritage. The region also hosts seven nation-al-level nature reserves and 28 national AAAA grade or above scenic spots, making it abundant in natural ecological resources.

The Xiangxi region is one of the most famous tourist destinations in China, with the tourism industry accounting for more than 50 percent of regional GDP and contributing more than 70 percent to economic growth, and tourism has become a pillar industry in the Xiangxi region. Currently, hundreds of villages in Xiangxi region have been developed for tourism, and a large number of farmers family have been affected by rural tourism, which plays an important role in promoting regional development and enhancing the livelihoods of farming families. However, while rural tourism has had a profound impact on the livelihoods of local farmers, it has also significantly damaged the rural ecological environment. Particularly in ethnic minority areas, rural tourism has led to the destruction of many traditional buildings, as well as significant changes in the livelihoods of farmers and the gradual extinction of ethnic cultures, with indelible effects on ecological resilience. Following preliminary research and a comprehensive evaluation of factors such as the scale of rural tourism operations, social benefits, and tourism development intensity, eight tourism villages were selected as research subjects: Disun Village and Huangdu Village in Jingzhou County, Huaihua City and Zhushan Village in

TABLE 1 Indicator system for measuring ecological resilience in tourism villages from farmers' perspectives.

Target layer	Layer	Index	Variable description and assignment	Weight
Ecological resilience	Pressure index 0.3131	Number of family surplus laborers C_1	1 = 8 people and above; 2 = 6–7 people; 3 = 4–5 people; 4 = 2–3 people; 5 = 1 people	0.0413
		Monthly energy costs C_2	1 = above 501 RMB; 2 = 301–500 RMB; 3 = 201–300 RMB; 4 = 101–200 RMB; 5 = within 100 RMB	0.0402
		Land pesticide costs C_3	1 = above 181 RMB; 2 = 121–180 RMB; 3 = 61–120 RMB; 4 = 1–60 RMB; 5 = 0 RMB	0.0702
		Land fertilizer costs C_4	1 = above 601 RMB; 2 = 321–600 RMB; 3 = 161–320 RMB; 4 = 81–160 RMB; 5 = within 80 RMB	0.0548
		Transportation mode C_5	1 = car; 2 = motorcycle; 3 = bus; 4 = electric vehicle; 5 = walking	0.058
		Homestead area C_6	1 = 181 m^2; 2 = 151–180 m^2; 3 = 121–150 m^2; 4 = 81–120 m^2; 5 = within 80 m^2	0.0486
	State index 0.2971	Type of access to subsidies C_7	1 = none; 2 = 1 type; 3 = 2 types; 4 = 3 types; 5 = above 3 types	0.0072
		Agricultural acreageC_8	1 = less than 0.1 hm^2; 2 = 0.1–0.2 hm^2; 3 = 0.2–0.3 hm^2; 4 = 0.3–0.4 hm^2; 5 = above 0.4 hm^2	0.0559
		Family forest land area C_9	1 = less than 0.1 hm^2; 2 = 0.1–0.3 hm^2; 3 = 0.3–0.6 hm^2; 4 = 0.6–1 hm^2; 5 = above 1 hm^2	0.1294
		Annual *per capita* income C_{10}	1 = within 5,000 RMB; 2 = 5,000–10,000 RMB; 3 = 10,000–20,000 RMB; 4 = 20,000–30,000 RMB; 5 = above 30,000 RMB	0.0204
		Education level of core family members C_{11}	1 = no educated; 2 = Primary school; 3 = Junior high school; 4 = Senior High school; 5 = College degree or above	0.0494
		Total household fixed assets C_{12}	1 = low; 2 = relatively low; 3 = general; 4 = relatively high; 5 = high	0.0348
	Response index 0.3898	Annual family education expenses C_{13}	1 = within 2,000 RMB; 2 = 2,000–5,000 RMB; 3 = 5,000–10,000 RMB; 4 = 10,000–20,000 RMB; 5 = above 20,000 RMB	0.0382
		Number of migrant farmers C_{14}	1 = none; 2 = 1 people; 3 = 2 people; 4 = 3 people; 5 = above 3 people	0.0531
		Monthly mobile phone communication costs C_{15}	1 = within 50 RMB; 2 = 50–80 RMB; 3 = 80–120 RMB; 4 = 120–150 RMB; 5 = above 150 RMB	0.0243
		Type of eco-policy understanding C_{16}	1 = none; 2 = 1 type; 3 = 2 types; 4 = 3 types; 5 = above 3 types	0.0807
		Number of family members engaged in tourism work C_{17}	1 = none; 2 = 1 people; 3 = 2 people; 4 = 3 people; 5 = above 3 people	0.1837
		Support for rural tourism development C_{18}	1 = very unsupportive; 2 = not very supportive; 3 = fairly supportive; 4 = commonly supportive; 5 = very supportive	0.0098

Fenghuang County, Dehang Village in Jishou City, Shibadong Village in Huayuan County, Laochehe Village in Longshan County, and Luotan Village and Maershan Village in Zhangjiajie City (Figure 2).

These villages were selected not only for their abundant natural resources, significant popularity with tourists, and the notable environmental impact of tourism development they evidence - the livelihoods of farmers in these villages are diverse in type and rich in information, providing a comprehensive reflection of the differentiation in farmers' household livelihoods and their ecological resilience under the influence of tourism development. Therefore, these eight tourism villages hold strong typicality and representativeness.

3.2 Data collection

To enhance the scientific rigor of this study, a diverse array of data collection methods was employed. Initially, basic information about the case-study villages was gathered from the official websites of each city (state) in Xiangxi Region. Subsequently, we conducted on-site investigations in December 2021, January 2022, and August-September 2022 to obtain detailed data on the livelihoods of farmers' households in the tourism villages through questionnaires and semi-structured interviews. The questionnaire content mainly includes the human capital, social capital, natural capital, physical capital and financial capital of farmers, changes in farmers' livelihood and farmers' behavior. Semi-structured interviews were used to investigate farmers' attitudes toward rural tourism, the process of rural tourism development and rural socio-economic conditions, and to support the questionnaire content. Ultimately, more than 100,000 words of text data and hundreds of hours of voice data were obtained, mainly including farmers' household livelihood capital, rural socio-economic conditions and farmers' behavioral activities (Zhao et al., 2023).

We employed a random sampling survey method to conduct a comprehensive survey of the farmers, dedicating 40–50 min per

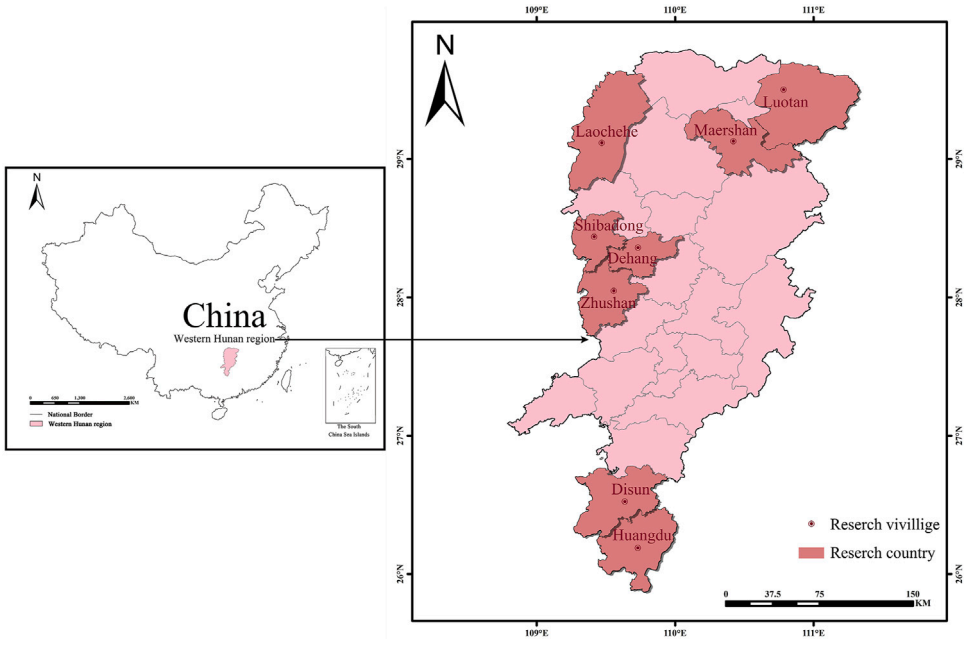

FIGURE 2
Location of study area: Xiangxi Region, China.

TABLE 2 Classification of farmer types.

Type	Quantity	Proportion	Annual household income (10,000 RMB)	Division basis
Tourism-led	37	9.92	14.54	Proportion of tourism income ≥60%
Labor-led	275	73.73	11.91	Proportion of working income ≥60%
Agriculture-led	30	8.04	5.63	Proportion of agricultural income ≥60%
Part-time Tourism	31	8.31	12.34	Proportion of tourism income <60%, multiple livelihoods including labor and agriculture

household. The respondents primarily consisted of the core family labor force (Yang et al., 2021), so as to be able to get a true and objective picture of the situation of farming families and rural tourism. The research team also immersed themselves in the daily activities of farmers in each case-study village, living alongside them and participating in farming, other work, and tourism management. This hands-on approach allowed us to experience the impacts of tourism-related disturbances on the rural social-ecological system from the farmers' perspectives (He et al., 2017). A total of 388 respondents were interviewed, and questionnaires and semi-structured interviews were conducted with all 388 farmers, obtaining 388 questionnaires and interview materials. After excluding abnormal questionnaires and questionnaires with missing information, 373 questionnaires were considered valid, accounting for 96.1% of the sample. The number of questionnaires collected in each case-study village exceeded 40, which satisfies requirements for the validity and representativeness of the research data (Xiao et al., 2023).

To systematically examine the disparities in ecological resilience among farmers, we referred to the classification of livelihood types utilized in a previous study (Wu et al., 2021). We integrated this framework with the specific conditions of our study area with household income as the basis for categorization. The interviewed farmers were classified accordingly into four distinct livelihood types: tourism-led, labor-led, agriculture-led, and part-time-led (Table 2).

In labor-led households, the primary income source is derived from work with a minimal supplement from agriculture. Tourism-led households, on the other hand, garner the majority of their income through engagement in tourism-related work—in these households, income from tourism constitutes more than 60% of the total. Part-time tourism-led households adopt a more diversified approach to livelihood, participating not only in tourism-related work but also in external labor or agricultural activities within the village. In contrast, agriculture-led types are limited to simple agricultural activities, resulting in lower household incomes than other types. These tend to be middle-aged and elderly individuals who have lost their abilities to engage in labor due to physiological reasons (e.g., illness).

3.3 Data analysis

3.3.1 Comprehensive index method

Ecological resilience is referred to in this paper as a composite of three dimensions: pressure, state, and response. Each of these dimensions is constituted of several indices. The composite index method was used to calculate the ecological resilience of farmers (Xie et al., 2023) with the following formula:

$$P_I = W_P \sum_{j=1}^{n} \omega j X_{ij} \quad (1)$$

$$S_I = W_S \sum_{j=1}^{n} \omega j X_{ij} \quad (2)$$

$$R_I = W_R \sum_{j=1}^{n} \omega j X_{ij} \quad (3)$$

$$E_I = P_I + S_I + R_I \quad (4)$$

where E_I is the ecological resilience index; P_I, S_I, and R_I denote the pressure index, state index, and response index, respectively. W_P, W_S, and W_R denote the weights of the pressure index, state index, and response index, respectively; ω_j represents the jth index layer weight and X_{ij} represents the standardized value of the ith index of the jth research unit.

3.3.2 Obstacle degree model

The obstacle degree model was used to analyze the obstacles hindering ecological resilience in tourism villages from the farmers' perspectives (Zhao et al., 2021). It was operated using the following formula:

$$P_{ij} = 1\text{-}X_{ij} \quad (5)$$

$$I_j = P_{ij}\omega_j \Big/ \sum_{j=1}^{n} P_{ij}\omega_j \times 100\% \quad (6)$$

where P_{ij} denotes index deviation, which indicates the gap between a single index and the optimal target value; I_j is the obstacle degree, which indicates the degree to which the jth index impedes ecological resilience; ω_j denotes the weight of a single factor on the total target, or the weight of the jth index with respect to ecological resilience.

3.3.3 SPSS 24.0 statistical analysis software

SPSS 24.0 statistical analysis software was used for factor analysis. Cronbach's alpha coefficient was used to test the reliability of the original data obtained from the questionnaire research. KMO test coefficient and Bartlett's test coefficient were used to test the validity of the original data. The results show that the Cronbach's α coefficient is 0.755. It is generally believed that when the Cronbach's α coefficient reaches 0.7–0.8, the scale has considerable reliability. The KMO test coefficient (0.776) is greater than 0.5, and the Bartlett test coefficient (Sig.) is 0.000, which indicates that the validity of the measurement index is well tested.

4 Results

The interviewee demographics exhibited minimal gender disparity, primarily comprising middle-aged and elderly (40 years of age and over) individuals (88%). The population was predominantly Miao (50%), with a majority holding an elementary school education or below (54%). Per capita annual income for farmers' households mainly fell within the range of 10,000–20,000 RMB (53%). The vast majority of these households gained their income by working outside the home (90%), indicating that the predominant type of farmer in the region is labor-led (Table 3).

4.1 Characteristics of ecological resilience of farmers in tourist villages

Equations 1–4 were applied to compute the farmers' ecological resilience index and the indices for each dimension of the PSR model. The pressure index, state index, response index, and ecological resilience index were 0.1631, 0.1263, 0.1337, and 0.4231, respectively (Figure 3). The natural breakpoint method was utilized to classify the in-dices of these dimensions into three levels: low, medium, and high. Among them, we observed low (0.0103–0.1186), intermediate (0.1187–0.1821), and high (0.1822–0.2786) levels of the stress index; low (0.0054–0.01040), intermediate (0.1041–0.1721), and high (0.1722–0.2641) levels of the state index; and low (0.0169–0.1110), intermediate (0.1111–0.1845), and advanced (0.1846–0.3068) levels of the resilience index. The ecological resilience low level (0.2087–0.3725), intermediate level (0.3726–0.4704), and advanced level (0.4705–0.7320) were also determined. Statistical analysis indicated that the index of ecological resilience for farmers in tourism villages in Xiangxi Region accounted for 31%, 39%, and 30% of low, medium, and high levels, respectively, with the mean value falling into the medium-level range.

4.2 Ecological resilience in farmers' households with different livelihood types

To further explore the nuances of livelihood differentiation and the divergence in ecological resilience among farmers' households after tourism-related disturbances, we conducted a statistical analysis of the ecological resilience indices of households with varying livelihood types (Figure 4; Table 4). The ecological resilience indices of different livelihood types of farmer households were, in descending order: part-time-led (0.4590), tourism-led (0.4516), labor-led (0.4177), and agriculture-led (0.4001). Specifically, tourism-led farmers showed the highest response index (0.1766) but the lowest stress index (0.1499); part-time-led farmers exhibited a high status index (0.1376) and response index (0.1647), but a low stress index (0.1567). Labor-led farmers showed the highest stress index (0.1636), a relatively low response index (0.1306), and an extremely low status index (0.1216). Agriculture-led farmers exhibited the highest status index (0.1585), a relatively high stress index (0.1636), and the lowest response index (0.078). Overall, the majority of farmers in Xiangxi Region demonstrated medium-level ecological resilience and dimensional indices. Only the response index of agriculture-led farmers was relatively low, and there was substantial convergence of the dimensional indices among farmers of different livelihood types.

The stress indices for various livelihood types were, in descending order: labor-led (0.1655), agriculture-led (0.1636),

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TABLE 3 Basic data for farmers in research sample.

Item	Form	Numbers	Proportion	Item	Form	Numbers	Proportion
Age	≤18	4	0.01	Gender			
	19–25	5	0.01		Male	192	0.51
	26–40	39	0.10		Female	181	0.49
	41–60	185	0.50	Educational level	Primary and below	202	0.54
	≥61	140	0.38		Junior high school	128	0.34
Nation	Han				Senior high school	34	0.09
	Tujia	133	0.36		College degree or above	9	0.02
	Miao	186	0.50	Annual *per capita* household income/10,000 RMB	≤0.5	12	0.03
	Dong	54	0.14		0.5–1	22	0.06
Income sources	Engaged in Tourism work	184	0.49		1–2	198	0.53
	Migrant farmers	334	0.90		2–3	64	0.17
	Farmers	88	0.24		≥3	77	0.21

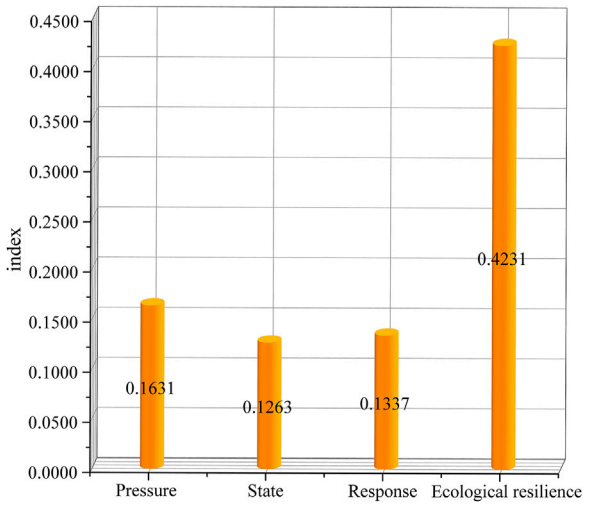

FIGURE 3
Dimensional indices and ecological resilience of farmers in Xiangxi Region.

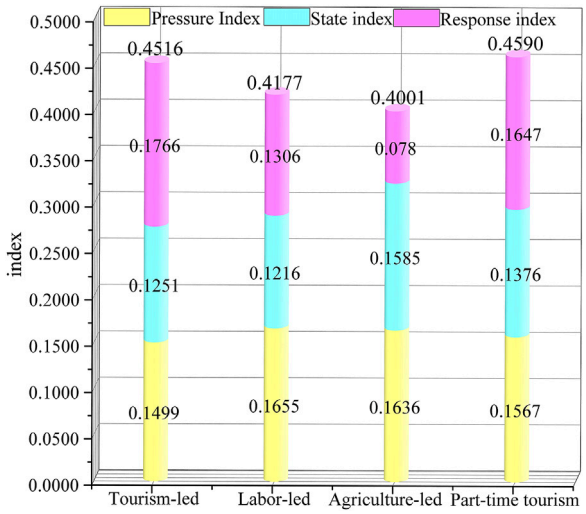

FIGURE 4
Dimensional and ecological resilience indices for farmers of different livelihood types.

part-time-led (0.1567), and tourism-led (0.1499). The mean value of the overall stress index fell within the medium range (Figure 5). The lowest stress index observed for tourism-led farmers implies that this type exerts the most significant disturbance on the rural social-ecological system. This phenomenon can be primarily attributed to the variability in livelihood-related behaviors among tourism-led farmers.

Tourism-led farmers' households exhibited the lowest indices for monthly energy costs C_2, transportation mode C_5, and homestead area C_6, while showing the highest indices for pesticide costs C_3 and fertilizer costs C_4. These results indicate that farmers change their livelihoods through participation in tourism, thereby reducing the environmental impact of agricultural cultivation. However, as their income increases and their quality of life improves, the acquisition of cars, expansion of homes, and more widespread energy consumption exacerbate the disturbance to the rural social-ecological system. Despite these nuances, tourism-led farmers still maintain the lowest overall stress index. Conversely, labor-led farmers do not strictly rely on traditional agriculture and have a lower demand for rural resources, so their overall level of disturbance to the rural social-ecological system is relatively low; therefore, their stress index is the highest.

The state indices for different livelihood types, in descending order, are: agriculture-led (0.1585), part-time-led (0.1376), tourism-led (0.1251), and labor-led (0.1216). The mean value of the overall

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TABLE 4 Ecological resilience indicators for households of different livelihood types.

	Tourism-led		Labor-led		Agriculture-led		Part-time-led	
	Mean value	Standard Deviation	Mean value	Standard Deviation	Mean value	Standard Deviation	Mean value	Standard deviation
Number of family surplus laborers C_1	0.0165	0.0081	0.0156	0.0085	0.0196	0.0097	0.0160	0.0078
Monthly energy costs C_2	0.0139	0.0115	0.0215	0.0109	0.0278	0.0081	0.0195	0.0102
Land Pesticide cost C_3	0.0484	0.0263	0.0446	0.0276	0.0334	0.0309	0.0402	0.0300
Land fertilizer cost C_4	0.0352	0.0173	0.0340	0.0197	0.0201	0.0199	0.0327	0.0193
Transportation mode C_5	0.0212	0.0210	0.0304	0.0185	0.0397	0.0187	0.0295	0.0190
Homestead area C_6	0.0148	0.0117	0.0195	0.0096	0.0231	0.0091	0.0188	0.0111
Type of access to subsidies C_7	0.0058	0.0013	0.0051	0.0013	0.0051	0.0009	0.0055	0.0011
Agricultural acreage C_8	0.0291	0.0154	0.0280	0.0179	0.0382	0.0157	0.0288	0.0191
Family forest land area C_9	0.0323	0.0398	0.0406	0.0422	0.0776	0.0454	0.0553	0.0451
Annual *per capita* income C_{10}	0.0137	0.0057	0.0128	0.0048	0.0082	0.0049	0.0135	0.0048
Education level of core family members C_{11}	0.0230	0.0108	0.0181	0.0113	0.0152	0.0082	0.0175	0.0112
Total household fixed assets C_{12}	0.0212	0.0096	0.0171	0.0079	0.0142	0.0094	0.0169	0.0088
Annual family education expense C_{13}	0.0214	0.0114	0.0184	0.0106	0.0172	0.0094	0.0200	0.0117
Number of migrant workers C_{14}	0.0047	0.0063	0.0250	0.0130	0.0075	0.0082	0.0184	0.0073
Monthly mobile phone costs C_{15}	0.0140	0.0056	0.0145	0.0060	0.0095	0.0062	0.0150	0.0055
Type of eco-policy understanding C_{16}	0.0485	0.0227	0.0374	0.0277	0.0242	0.0262	0.0371	0.0271
Number of family members engaged in tourism work C_{17}	0.0795	0.0422	0.0272	0.0378	0.0122	0.0312	0.0652	0.0383
Support of rural tourism development C_{18}	0.0086	0.0019	0.0080	0.0023	0.0074	0.0018	0.0090	0.0014

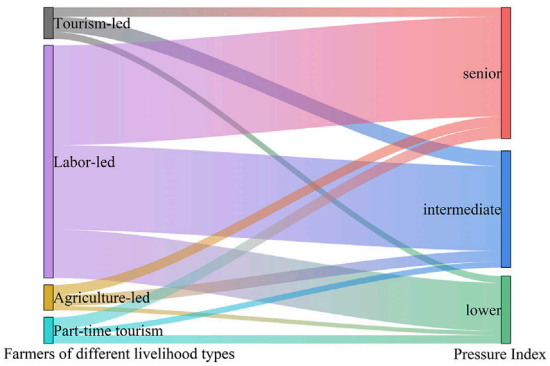

FIGURE 5
Correspondence of stress indices for households with different livelihood types.

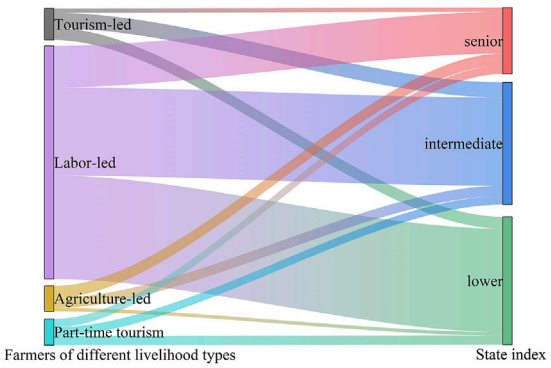

FIGURE 6
Correspondence of state indices for households with different livelihood types.

state index falls into the intermediate range (Figure 6). Agriculture-led households exhibited the highest values for agricultural acreage C_8 and family forest land area C_9, indicating that agricultural livelihoods contribute to maintaining productive land in rural areas and safeguarding the ecological functions of the countryside. In contrast, labor- and tourism-led livelihoods, while

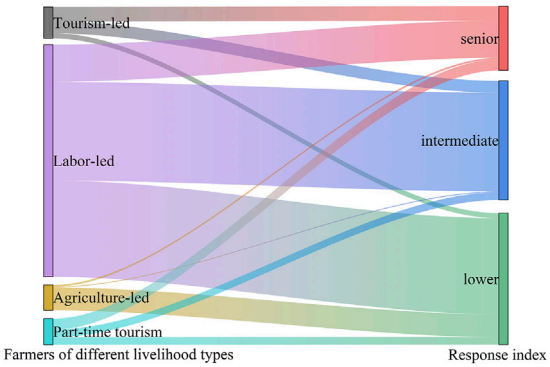

FIGURE 7
Correspondence of response indices of house-holds with different livelihood types.

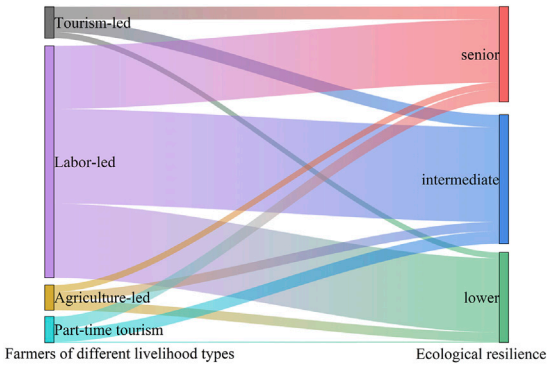

FIGURE 8
Correspondence of ecological resilience indices of households with different livelihood types.

enhancing house-hold income, cause damage to the environment through practices such as land abandonment and transfers. The development of tourism has not only contributed to the diversification of farmers' household livelihoods but has also intensified their exploitation of rural resources and the environment.

The response indices for different livelihood types were, in descending order: tourism-led (0.1766), part-time-led (0.1647), labor-led (0.1306), and agriculture-led (0.0780). The former three types had medium-level response indices while the latter had a low response index (Figure 7). This ranking primarily reflects the farmers' capacities to access information and adapt their livelihoods to the development of tourism. Tourism-led farmers demonstrated the highest indices for annual family education expenses C_{13}, type of eco-policy understanding C_{16}, and the number of family members engaged in tourism work C_{17}, among other indicators. The substantial impact of tour-ism development on the livelihoods of farmers' households, resulting in higher in-comes and enhanced awareness, effectively improved the decision-making abilities of these households and influenced their choices of livelihood. Additionally, an influx of tourism capital led to the restructuring of rural social networks, motivating farmers to actively engage in tourism-related work and adjust their livelihood-related behaviors to the benefit of the rural social-ecological system. Agriculture-led households, despite possessing relatively abundant productive land, exhibited a weaker ability to access information and transform their livelihoods. Consequently, they showed the lowest levels of each indicator and the lowest response indices among the farmer types.

The ecological resilience indices of farmers' households of different livelihood types are, in descending order: part-time-led (0.4590), tourism-led (0.4516), labor-led (0.4177), and agriculture-led (0.4001) (Figure 8). The mean value of the overall ecological resilience index falls into the intermediate range, which aligns with the field research findings. This outcome was primarily shaped by the specificities of the house-holds' livelihood types. Diversified livelihoods are conducive to securing farmers' living standards, providing more access to social resources and information (Becken, 2013). Farmers, as the mainstay of rural communities, can enhance their social cognition and behavior through participation in the tourism sector (Wu et al., 2023), contributing to improved state and response indices. Despite fostering diversified livelihoods, tourism development also intensifies the demand for rural resources, alters resource utilization practices, initiates land transfers, and introduces the construction of tourism-related projects, resulting in significant disturbances to the rural ecological environment. Overall, diversified livelihoods contribute more effectively to the sustainability of rural social-ecological systems (Chen et al., 2017). Rural tourism should be planned and developed under the premise of protecting the ecological environment.

4.3 Obstacles to ecological resilience

The obstacle degree model serves to elucidate the relationships between system factors and reveal the impact of each indicator on the system based on the magnitude of the obstacle degree. In the context of farmers' ecological resilience, a higher obstacle degree for a given indicator implies a more adverse effect on ecological resilience improvement, and *vice versa*. Eqs 5, 6 were used to calculate the obstacle degree of each index. A cumulative obstacle degree exceeding 50% can be regarded as indicating a primary obstacle factor (Zhao et al., 2021). In this study, the obstacle factors of ecological resilience were ranked for different livelihood types. We screened the common obstacle factors for different livelihood types accordingly (Table 5).

The number of family members engaged in tourism work, family forest land area, and the awareness of ecological policies emerged as common obstacle factors for different livelihood types. Among them, the number of family members engaged in tour-ism work C_{17} was the primary obstacle factor for all four types, with obstacle degrees of 18.90%, 26.91%, 28.86%, and 21.76%, respectively. The problem of low participation among households is prevalent in rural tourism development processes. Though farmers' households can transform their livelihoods and enhance the stability of their livelihood system through participation in tourism-related work, they are often excluded from municipal or regional decision-making due to the weak foundation of their livelihoods (Chen et al., 2022).

Furthermore, as a key element of the rural social-ecological system in terms of maintaining ecological functions, forest land is a

TABLE 5 Ecological resilience obstacles for farmers of different livelihood types.

Livelihood type	Obstacle factor	Obstacle degree (%)	Rank	Accumulation (%)
	Number of family members engaged in tourism work C_{17}	18.9	1	18.90
	Family forest land area C_9	17.22	2	36.12
Tourism-led	Type of eco-policy understanding C_{16}	8.98	3	45.10
	Education levels of core family members C_{11}	6.95	4	52.05
	Homestead area C_6	6.29	5	58.34
	Number of family members engaged in tourism work C_{17}	26.91	1	26.91
	Family forest land area C_9	14.87	2	41.78
Labor-led	Type of eco-policy understanding C_{16}	7.43	3	49.21
	Education levels of core family members C_{11}	5.42	4	54.63
	Homestead area C_6	5.17	5	59.80
	Number of family members engaged in tourism work C_{17}	28.86	1	28.86
	Type of eco-policy understanding C_{16}	9.3	2	38.16
Agriculture-led	Family forest land area C_9	8.03	3	46.19
	Number of migrant workers C_{14}	7.77	4	53.96
	Pesticide costs C_3	5.91	5	59.87
	Number of family members engaged in tourism work C_{17}	21.76	1	21.76
	Family forest land area C_9	13.33	2	35.09
Part-time-led	Type of eco-policy understanding C_{16}	7.82	3	42.91
	Number of migrant workers C_{14}	6.57	4	49.48
	Education levels of core family members C_{11}	5.87	5	55.35

critical indicator of ecological resilience. Tourism development often results in significant transfers of rural forest land to construction areas, which adversely affects ecosystem services and directly diminishes ecological resilience. The proactive role of farmers is decisive in rural ecological governance; farmers' ecological awareness influences their daily activities and livelihood-related behaviors, directly impacting the ecological environment.

In addition to the three common obstacle factors, the education levels of core family members C_{11} and homestead area C_6 also emerged as significant impediments to the ecological resilience of farm households. The field research data revealed that 54% of the farmers' households had received only elementary school educations, only 34.4% had received junior high school educations, and only 11.6% had received senior high school educations or above. The inefficiency of rural education resources has led to a relatively overall education quality for farmers' households, hindering behavior that would be advantageous to the rural social ecosystem. These relatively low levels of education can lead farmers to interfere with or even directly damage the ecological environment in their daily lives—a phenomenon that is commonly observed in under-developed regions (Raleigh, 2011). Simultaneously, rural areas experience significant land resource waste while unregulated construction practices severely damage the natural environment. Therefore, rational planning and development to encourage the effective usage of rural resources are necessary measures to promote enhanced ecological resilience. Obstacle factors impeding ecological resilience across different types of rural households, such as low enthusiasm for participation in tourism development, restricted access to information, and minimal investment in education, were found to be prevalent in the case-study region. These factors significantly impede the improvement of rural areas' ecological resilience.

5 Discussion and conclusion

5.1 Discussion

Rural tourism has evolved into a pillar industry for the economic development of ethnic areas, creating a significant challenge in terms of achieving synergistic development between the ecological protection of tourism villages and the livelihoods of rural residents (Pjerotic et al., 2017). Within rural social-ecological systems, ecological resilience is not only affected by external social-economic factors but also by the pressure on the environment stemming from farmers' behavior, the altered state of households' livelihood systems following tourism-related disruptions, and the responsiveness of farmers in adjusting their behaviors to improve their local areas (Latkova and Vogt, 2012). Integrating farmers' house-hold livelihoods and behaviors into an analysis framework of rural social-ecological systems can expand the

scope of ecological resilience research. Targeted findings from farmers' perspectives may also deepen ecological resilience research at a conceptual level.

The results of this study revealed an overall low level of ecological resilience among rural residents in tourism villages of Xiangxi Region, primarily attributable to the nascent stage and uneven progress of rural tourism development (Latkova and Vogt, 2012). Infrastructure construction and tourism project implementation, marked by large-scale land acquisition and transfer, have significantly disrupted the ecological environment (Assiouras et al., 2022). However, positive effects on ecological resilience were observed in cases where local governments and community management organizations actively protected rural resources (Lin, 2020). Conversely, farmers' livelihood-related behaviors may have caused two-way interventions in rural ecosystems, highlighting the dual impact of tourism development on rural ecological resilience and necessitating positive, nuanced policy constraints (Li et al., 2022).

The specificity of certain livelihoods contributes to variability in ecological resilience among different types of farmers (Lin, 2020). Farmers' participation in tourism development plays a crucial role in enhancing their families' stability and adapting to tour-ism-related changes in their environment. However, the weak foundation of their livelihoods and unequal positions in local decision-making processes make many tourism villages a "the game of the few" (Xiao et al., 2023). Enhancing rural households' participation in tourism development and increasing the incomes of agricultural workers are pivotal factors for promoting the ecological resilience of the countryside. Additionally, there is a notable convergence of ecological resilience obstacles across various livelihood types, primarily stemming from the limited options for earning one's livelihood in an under-developed region (Zhang et al., 2022). Resource constraints hinder regional economic development and rural households' livelihoods, leading to rural tourism featuring state leadership, tourism-company interventions, and, ideally, the participation of rural residents. However, cases that genuinely benefit farmers are scarce. To achieve sustainable development, rural tourism development must not only provide financial income but also create opportunities for rural households to gain stable livelihoods.

There are various research methods and indicators on rural ecological resilience, however, few scholars have explored rural ecological resilience from the perspective of farmers, and the role of farmers' livelihoods and behavioral interventions in rural socio-ecological systems has often been overlooked. The main contribution of this study is to introduce the PSR framework into the rural socio-ecological system, emphasizing the important role of farmers' subjective initiative on rural ecosystems. This study contributes to a more comprehensive assessment of rural ecological resilience, and can provide a new perspective for a deeper understanding and cognizance of the interrelationships between farm households and rural social-ecological systems.

5.2 Conclusion and recommendations

This study constructed a framework for analyzing the ecological resilience of tourism villages from the perspective of farmers, and explored the differentiated characteristics and obstacles of ecological resilience of different types of farmers in a Chinese ethnic minority area. The main conclusions are as follows. First, there are differences in the ecological resilience of different types of farmers. The primary factors contributing to these differences were the immaturity of the rural tourism sector and the un-even level of tourism development across the region. Second, the overall level of ecological resilience in Xiangxi region is sub-par, reflecting the weak foundation for farmers' livelihoods in ethnic areas. Last, There is a convergence of barriers to ecological resilience among different types of farmers, which is mainly determined by the specificity of the economic backwardness of the Xiangxi region. Therefore, more support needs to be given to ethnic minority villages and farmers in order to realize the sustainable development of tourist villages.

Based on the results of the study, we offer several recommendations for improving the ecological resilience of tourism villages in underdeveloped regions and ethnic areas globally. Firstly, the government should adopt a macro-control role, guided by scientific planning, to ensure tourism development aligns with ecological protection. Adequate policy support and financial support should be provided to create conducive investment and employment conditions for rural tourism. Secondly, community management organizations should leverage regional characteristics and cultural resources to establish a diversified tourism industry chain, enhancing competitiveness and creating more local job opportunities. This would also encourage farmers to remain in (or return to) their hometowns to start their own businesses and bolster the local economy. Finally, farmers should actively engage in rural tourism work, continuously improving their skills and transforming their livelihoods in accordance with the influx of tourism. They should enhance their ecological and environmental awareness, applying this knowledge to rural production and daily living practices to prevent resource wastage and achieve harmonious coexistence with nature.

There are some limitations to this study, such as the small sample size of the study and the lack of research on the dynamics of ecological resilience in tourist villages. We assessed the ecological resilience of tourism villages from farmers' perspectives using cross-sectional data. However, this approach fell short of fully elucidating the evolutionary characteristics and influencing mechanisms of farmers' ecological resilience in tourism villages in ethnic areas. Subsequent research efforts should expand the scope of the survey, increase the sample size of the study, as well as follow up on farm household livelihood data over time to enhance the robustness and comprehensiveness of the findings.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Jishou University Biomedical Ethics Committee. The studies were conducted in accordance with the local legislation and

institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JW: Conceptualization, Funding acquisition, Supervision, Writing–original draft, Writing–review and editing. YY: Formal Analysis, Investigation, Supervision, Writing–review and editing. JZ: Investigation, Writing–review and editing. QC: Investigation, Writing–review and editing. DG: Investigation, Writing–review and editing. SL: Methodology, Writing–review and editing.

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Conflict of interest

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

Publisher's note

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