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Investigating climate change perceptions and behaviors from a microscopic perspective in four mountain villages in Taiwan

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Formulating climate change adaptation strategies based on local perceptions and behaviors, especially in mountainous areas, is challenging for managers. This study aims to identify the risk perception, avoidance behaviors, and adjustment strategies of residents in different mountain villages within the same township. A census was conducted through questionnaire-based onsite surveys, collecting 302 responses from four mountain villages in the Shuilixi township of Nantou County. The results indicate that Han people perform significantly better than indigenous people in avoidance behavior and adaptation strategies due to better socio-economic conditions. Significant differences emerge among four groups: indigenous in high-risk areas, Han in high-risk areas, indigenous in low-risk areas, and Han in low-risk areas. Residents in low-risk areas, regardless of ethnicity, outperform those in high-risk areas in climate risk perception, avoidance behavior, and adaptation strategies. Respondents from different backgrounds (gender, age, income, occupation) in low-risk areas also fare better in these aspects. Notably, residents in high-risk areas exhibit lower actual avoidance behavior than their perceived behavior, possibly due to limitations in occupation, education, income, or available space. The study highlights significant differences in ethnic distribution and geographical features within small-scale villages in the upper Shuili stream area. It suggests that future research should compare towns and villages in different geographical locations for a broader understanding of population characteristics and that climate change disaster prevention planning should be considered on a village-by-village basis.

KEYWORDS

climate change, risk perception, avoidance behavior, adaptation strategy, local residents, mountain village

1 Introduction

While many researchers have focused on proposing effective policies and tools, such as environmental taxation, to reduce pollutant emissions and mitigate climate change (Huru et al., 2024) or constructing risk maps to effectively reduce risk of disturbances and preserve ecosystem services (Navarro-Cerrillo and Ariza-Salamanca, 2024), Climate change knowledge, social media, values, and social norms were each directly associated with behavioral adaptation (Sattler et al., 2023), adaptation strategies for residents in mountainous areas remain largely overlooked. Therefore, formulating climate change adaptation strategies based on local perceptions and behaviors, especially in mountainous areas, is a challenging task for managers. Global warming has accelerated changes in mountain ecosystems (Pepin et al., 2015), leading to more frequent and intense climate disasters in mountain villages compared to urban areas. This exacerbates economic losses in agriculture and forestry, impacting downstream food security and price stability. To address this, climate adaptation strategies should consider past actions and be embedded in broader social and political contexts (Wyborn et al., 2015).

Generally, residents' risk perception and avoidance behavior reflect their climate adaptation strategies. Risk perception refers to an individual's understanding of the dangers of climate change, while avoidance behavior refers to the actual actions taken to tackle climate change. Adaptation strategies are the countermeasures expected to address climate change issues. Risk perception is shaped by an individual's knowledge (Tenkorang, 2018). For example, one's self-assessment of potential hazards in a fragile environment is a subjective perception of risks (Plapp and Werner, 2006). Many studies have explored whether an individual's risk perception affects subsequent behavior. Existing research has pointed out a positive impact (Peng et al., 2019) and considers risk perception key to predicting individual preventive behavior (Lu et al., 2021; Majid et al., 2020). For example, residents with higher risk perceptions of disasters such as floods and droughts actively adopt different adaptation strategies (Gioli et al., 2014). Those with higher risk perceptions of epidemics such as influenza and COVID-19 are more likely to take proactive approaches (Krok and Zarzycka, 2020). However, Ahmed et al. (2019) favored the correlation between individual risk perception and subsequent behavior but did not reach a clear conclusion.

Indigenous people in mountainous areas often adopt traditional ecological wisdom as their cultural mindset for taking actions, which drives improvement in tribal resilience to disasters from climate change (Wu and Chen, 2020). Therefore, traditional knowledge (TK) or traditional ecological knowledge (TEK) plays an important role in disaster risk reduction (DRR). The United Nations point out that integrating local people's traditional knowledge (Indigenous traditional knowledge) helps cope with climate change (Rai and Khawas, 2019; Bethel et al., 2022; Wang and Tien, 2009). By traditional ecological knowledge (TEK), scholars have concluded that risk tolerance varies across different agricultural systems. Greater diversity within an agricultural system enhances its sustainability and resilience. There are three ways to increase rural diversity: diversifying agricultural activities in agricultural areas, increasing non-agricultural activities for farmers, and diversifying economic activities in agricultural areas (Quaranta and Salvia, 2014; Pedreño et al., 2015). Additionally, heterogeneous agricultural landscapes are crucial for strengthening agricultural resilience. Higher levels of heterogeneity can reduce risks, although this approach may involve trade-offs, such as reduced average returns despite decreased instability (Abson et al., 2013). Some scholars in agriculture and animal husbandry have explored strategies using local knowledge in response to climate change, applied them to prediction and planning (Ashraf et al., 2014; Alam et al., 2016; Wilmer et al., 2019; Apraku et al., 2021; Yeleliere et al., 2022; Streefkerk et al., 2022), and to research fields such as fish harvesting and habitat management in oceans or rivers (de Echeverria and Thornton, 2019; Mabe and Asase, 2020; Gianelli et al., 2021; Tsang et al., 2021; Hoang et al., 2022).

Effective disaster prevention and relief require using TEK and considering tribal beliefs, culture, and tourism development to strengthen community resilience (Wang and Chen, 2015; Wang and Lin, 2020). Though the indigenous peoples may rely on TEK to mitigate natural disasters, their disaster awareness is relatively weak, and they are more willing to take risks due to their close ties to the land (Lin and Lin, 2020). When dealing with climate change issues, it is hard for local leaders to integrate local data with broad-scale information (McAllister et al., 2019). Including indigenous communities in disaster prevention mechanisms through cross-sector collaborations and respecting their autonomy is important (Lin et al., 2019), but limiting decision-making power to certain genders, ethnic groups, or social statuses can harm these communities (McLeod et al., 2018). For example, men are more concerned about high temperatures and ocean management issues, while women are more concerned about storms and related dangers, pollution control and other issues (Alston, 2014). Women in different tribal roles have less understanding and enthusiasm for local adaptation strategies due to lack of participation. (Cassinat et al., 2022). Moreover, media information plays a crucial role in shaping climate change strategies for indigenous communities, such as those in Rangamati Sadar of Bangladesh. These communities often gain awareness of climate change through various media sources, which influence their adaptation responses. In turn, they have developed localized strategies, including planting trees around their homes, engaging in religious practices, providing mutual aid, seeking financial support for investments, applying indigenous technologies, and even changing occupations to cope with environmental shifts (Garai et al., 2022).

Taiwan, a geologically fragile mountainous island, frequently faces natural disasters impacting its agriculture and forestry sectors. Indigenous groups like the Paiwan, Rukai, Tao, Atayal, and Seediq have developed adaptive strategies using traditional ecological knowledge (TEK), such as heterogeneous farming systems and crop rotation, to maintain livelihoods despite natural disasters. There are significant perceptual and behavioral differences in response to climate change among different genders, ethnic groups, education levels, and tribal roles (Wang et al., 2017; Findlater et al., 2018; Ma et al., 2006; Cassinat et al., 2022). Higher social, natural, and intellectual capital stocks reduce the negative impacts of climate anomalies on tribal agricultural production (Wang, 2016). For instance, aborigines adapt to climate-induced phenomena by eliminating unsuitable crops, using greenhouses, and selecting appropriate arable land (Wang, 2013). The Bunun select stable slopes for their homes to ensure sunlight and wind protection, away from unstable land and near water sources (Lumaf, 2010). The Paiwan and Tsou use specific slopes and terraces to avoid landslides and mitigate disaster risks (Cheng, 2010). While indigenous contributions to disaster management are crucial, most studies are qualitative and lack quantitative analysis (Kuan, 2015; Kuan, 2017).

Identifying the perception, attitude and behavior of residents in high-risk communities from a micro perspective is a key factor in preventing natural disasters. Most research focuses on discussing residents' perceptions and avoidance behaviors in large-scale areas such as townships or counties. However, there are notable differences among villages within the same township or county. Since Nantou County is evaluated as a potentially dangerous area with various ethnic groups living in mountain villages (Tsai et al., 2005), this study focuses on the residents of four mountain villages in the Shuilixi catchment area of Nantou County. The purposes of this study are to identify the risk perception, avoidance behaviors, and adjustment strategies of residents in different mountain villages within the same township. Finally, recommendations are proposed for strategic planning scales for future research on climate change and disaster prevention-related issues in mountainous areas.

2 Materials and methods

2.1 Research area and respondents

Nantou County is located in central Taiwan, with hillside slopes accounting for 95% of the total area. Since the 1990s, natural disasters such as Typhoon Herb, the 921 Earthquake, and Typhoon Toraji have caused severe damage. Consequently, the government has designated it as a priority area for soil and water conservation. According to the Debris Flow and Large-Scale Landslide Disaster Prevention Information Network of the Council of Agriculture, Nantou County has 262 streams with potential for landslides, 10 of which are listed as priority areas for large-scale collapses, with significant prevention achievements noted in five of them. Agriculture was traditionally the main industry in Nantou County, but in recent years it has gradually shifted towards integrated tourism (Kuo et al., 2019). For example, Shang'an Village has actively promoted community building after disasters to develop diversified agricultural industries such as plums, tea, and grapes, which are key crops for industrial revitalization (Chen et al., 2010).

To analyze whether there are notable differences among villages within the same township or county, it is necessary to narrow the research scope to a smaller scale to identify the characteristics of groups with different risk levels in the same area. Considering transportation accessibility, respondent willingness, and regional differences between upstream, midstream, and downstream areas, four villages from two townships in the Shuilixi catchment area were selected for surveys based on low-to-high vulnerability criteria: Shang'an Village of Shuili Township, and Renhe Village, Fengqiu Village, and Dili Village of Xinyi Township. The Bunun are the main ethnic group in Shuili and Xinyi Townships, accounting for 65.18% and 93.38% of the population respectively.

The Bunun people have long relied on hunting, medicinal, and food plants, which remain integral to their cultural memory and traditional practices. Ethnobotanically significant species primarily belong to the dominant plant families Gramineae, Asteraceae, and Lauraceae, and their usage involves complex traditional knowledge systems passed down through generations (Tung and Haivangang, 2009). Over time, dietary habits have shifted, with rice and sweet potatoes becoming staple foods, while wild edible plants and fungi continue to serve as important non-staple supplements. Among these, pigeon pea is particularly notable, primarily used in soups as a key non-staple ingredient. In addition to dietary practices, Bunun rituals play a crucial role in reinforcing cultural traditions. Malahtangian, the most significant annual ritual, is dedicated to praying for a successful hunting season and agricultural harvest, reflecting the community's dependence on both hunting and farming. Malastapang, led by individuals of high prestige, serves as a platform for men to declare their hunting achievements and past participation in headhunting, a practice historically significant in Bunun society (Council of Indigenous People (CIP), 2025, March 15). Furthermore, the Bunun people are traditionally divided into five branch groups, each exhibiting distinct architectural styles that reflect their adaptation to local environmental conditions. In central Taiwan, houses are primarily constructed using black slate stone and wood, while in eastern and southern Taiwan, building materials include wooden posts and lintels, with thatched or bark roofs and bamboo walls being common features (Kwan, 2022). These architectural differences highlight the Bunun people's resourcefulness in utilizing locally available materials and demonstrate their deep connection to their natural surroundings.

Based on the survey year (2018), the basic social composition of each village is as follows: Shang'an Village is a mixed community of Fujian residents, with a registered population of 1,246 and a permanent population of about 1,100; Fengqiu Village is a mixed population of indigenous and Han people, with a registered population of 767 and a permanent population of about 500; Renhe Village is composed of different indigenous ethnic groups, with a registered population of 1,528 and a permanent population of about 700–800; 85% of the population in Dili Village is Bunun, with a registered population of 1,115 and a long-term resident population of about 800. Comparing Fengqiu and Shang'an Villages in the map of the studied area in Figure 1, both are located in relatively gentle areas in the middle and lower reaches of the terrain, with larger areas of available arable land and a longer average distance from rivers. Shuili Township is an important entrance and exit to these four villages. The road distances from Shangan Village to Renhe Village, Fengqiu Village and Dili Village are 24.7, 47.9 and 71.8 km respectively. It takes 78 km to travel from Renhe Village to Dili Village. Fengqiu Village and Dili Village are the farthest apart, with a driving distance of 116 km. The altitude of these two villages is about 600 m. In contrast, Dili Village and Renhe Village are situated in the upper mountainous region at an altitude of approximately 1,400 m, where residential areas, cultivated land, and rivers are more closely interwoven. Therefore, in terms of agricultural land distribution, the former two villages have 843 parcels of agricultural land, while the latter two have only 328. According to the Fiscal Information Agency, Ministry of Taiwan's Finance in 2023, the personal consolidated income in Fengqiu, Shang'an, Dili and Renhe Village is NTD 461,000, 350,000, 389,000 and 474,000, respectively.

Limitations in this study include difficulty in contacting respondents and high mobility in mountainous areas. Many residents cannot be reached due to work, schooling, or living with relatives. However, a census conducted through questionnaire-based onsite surveys collected a total of 302 responses, based on household registration record. After excluding one foreign respondent and one incomplete response, 300 valid questionnaires remained. As shown in Table 1, based on the research results of Lin et al. (2018), we labeled Fengqiu Village and Shang'an Village as low-risk vulnerability areas, whereas Dili Village and Renhe Village were classified as high-risk vulnerability

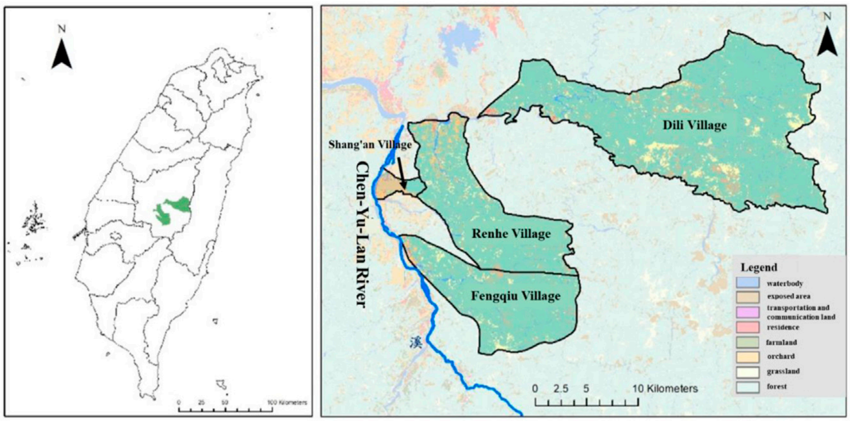

FIGURE 1
Map of the studied area in Taiwan.

TABLE 1 The population of the indigenous and Han people living in different risk areas.

	Indigenous people	Han people	Total
High risk area	155 (89.60)	18 (10.40)	173 (100.00)
Low risk area	78 (61.42)	49 (38.58)	127 (100.00)

Note: values given in parenthesis are percentage.

areas. In high-risk areas, 155 indigenous people and 18 Han people were surveyed, accounting for 89.60% and 10.40% of the population, respectively. In low-risk areas, 78 indigenous people and 49 Han people were surveyed, making up 61.42% and 38.58% of the population, respectively.

2.2 Questionnaire design

The questionnaire framework for this study involves four major aspects: climate change perception and attitude, climate risk avoidance behavior, climate disaster adaptation strategies, and background information. Each of the first three aspects is composed of 10 questions. To align with the actual experiences of the interviewees and avoid invalid answers, the content of each question was designed based on results compiled by the research team during on-site interviews. Prior to the formal survey, the questionnaire was validated by experts and scholars to ensure reliability and validity.

Questions in the climate change perception and attitude section include: "constantly worry about climate risks," "believe that climate disasters will worsen," "high temperatures will increase," "single rainfall events will become more intense," "climate change causes property losses," and "affects the lives of future generations."

The climate risk avoidance behavior section includes questions such as: "living or farming far away from river banks or landslide areas," "dispersing the planting of crops," "investing in greenhouse equipment," and "not needing high agricultural yields."

The climate disaster adaptation strategies section includes: "knowing how to choose safe areas for living and farming," "applying environmental knowledge," "undertaking disaster prevention work," "listening to the suggestions of farmers' associations," and "purchasing insurance and applying for subsidies."

All questions are designed using the Likert 5-point scale, with 5 representing "strongly agree" and 1 representing "strongly disagree." The background information section includes gender, age, ethnicity, education level, occupation, and other demographic details, using a nominal scale.

2.3 Statistical method

This study features exploring whether differences in factors such as regional differences and ethnic groups affect their disaster experience and risk awareness. In addition to describing and distinguishing ethnic groups through basic descriptive statistics, it mainly analyzes the differences in the questionnaires between different ethnic groups. The questionnaire data was first analyzed using Cronbach's α value and KMO value to conduct reliability and validity analysis on the three aspects of climate change perception and attitude, climate risk avoidance behavior, and climate disaster adaptation strategies, to test the consistency of the items in each aspect for subsequent analysis after confirming the items to be delete. This study used descriptive statistics, Chi-square test, and one-way multivariate analysis of variance (MAVOVA) to analyze differences in perception among three aspects such as climate change perceptions and attitudes, climate risk avoidance behaviors, and adaptation strategies against climate disasters. Of the adopted methods, one-way MANOVA can extend the capabilities of analysis to simultaneously compare means for multiple variables across groups, and can reduce the probability of type I error. In this study, the three facets of risk perception, avoidance behavior and adjustment strategies were tested by MANOVA. If each facet did not meet the homogeneity assumption, the Pillai's Trace value was observed; but when the variation numbers were homogeneous, the Wilks' Lambda value was

TABLE 2 The Chi-square test of ethnic group and risk area variables toward different social-economic status.

Age	Under 30	30–39	40–49	50–59	Over 60	χ^2 value
Indigenous people	69 (29.74)	35 (15.09)	46 (19.83)	49 (21.12)	33 (14.22)	11.208*
Han people	12 (17.91)	21 (31.34)	13 (19.40)	10 (14.92)	11 (16.42)	
Occupation	Agriculture, forestry, fishery or animal husbandry	Industry, business, military, civil servant or teacher	Service industry or student		Retiree or unemployed	
Indigenous people	65 (28.02)	26 (11.21)	67 (28.88)		74 (31.90)	13.748**
Han people	11 (16.42)	16 (23.88)	11 (16.42)		29 (43.28)	
Monthly income	Under 40 k	40–60 k	60–80 k		Over 80 k	
Indigenous people	155 (67.10)	28 (12.12)	31 (13.42)		17 (7.36)	34.049***
Han people	20 (29.85)	12 (17.91)	18 (26.87)		17 (25.37)	
Ethnic group	Indigenous people		Han people			
High risk area	155 (89.60)		18 (10.40)			33.525***
Low risk area	78 (61.42)		49 (38.58)			
Age	Under 30	30–39	40–49	50–59	over 60	
High risk area	55 (31.98)	16 (9.30)	25 (14.53)	44 (25.58)	32 (18.60)	39.509***
Low risk area	26 (20.47)	40 (31.50)	34 (26.77)	15 (11.81)	12 (9.45)	
Education	Under elementary school		Junior high school		Senior high school and above	
High risk area	46 (26.59)		44 (25.43)		83 (47.98)	13.048***
Low risk area	13 (10.24)		34 (26.77)		80 (62.99)	
Occupation	Agriculture, forestry, fishery or animal husbandry	Industry, business, military, civil servant or teacher	Service industry or student		Retiree or unemployed	
High risk area	66 (38.37)	21 (12.21)	35 (20.35)		50 (29.07)	36.219***
Low risk area	10 (7.87)	21 (16.54)	43 (33.86)		53 (41.73)	
Monthly income	Under 40 k	40–60 k	60–80 k		Over 80 k	
High risk area	135 (78.95)	18 (10.53)	8 (4.68)		10 (5.85)	75.101***
Low risk area	40 (31.50)	22 (17.32)	41 (32.28)		24 (18.90)	

Note 1: Values given in parenthesis are percentage.
Note 2: *p < 0.05, **p < 0.01, ***p < 0.001.

observed. Accordingly, the correlation between various aspects can be explained. The statistical software used in this study is SPSS version 16.0.

3 Results and discussions

From the returned questionnaires, we first analyzed whether there are differences between different ethnic groups in different socioeconomic conditions and backgrounds (Table 2). The research results show that there are significant differences across ethnic groups in only three variables: age, occupation and monthly family income. Sixty-nine indigenous respondents aged under 30, account for the highest proportion of this ethnic group, 29.74%, while there are only 12 Han people, accounting for 17.91% of this ethnic group. Among the Han respondents, the age cohort between 30 and 39 years has the highest proportion, 31.34%, but the indigenous age group of 30–39 years has only 15.09%. However, 21.12% of the indigenous people are aged 50 to 59, which is higher than the 14.92% of the Han people. As for those aged 40 to 49 and those aged 60 and above, the proportions of the two age cohorts are similar. In terms of occupational categories, the percentages of aboriginal people engaged in agriculture, forestry, fishery, animal husbandry, service industry versus students are 28.02% and 28.88% respectively, which is higher than those of Han people. However, percentages of Han people engaged in industry, commerce, military, public education *versus* retired or unemployed are 23.88% and 43.28% respectively, higher than those of indigenous peoples. In terms of monthly household income, as high as 67.10% of the aborigines is below the income bracket NT$ 40,000, whereas 70.15% of Han people's is above it.

Furthermore, this study uses Chi-square analysis to explore whether there are differences in gender, age, education and other backgrounds among respondents living in risk areas from different ethnic groups. First, the results of Chi-square analysis in Table 3 indicate that respondents in different risk areas differ significantly in terms of ethnicity, age, education level, occupation and income. In high-risk areas, the percentage of indigenous peoples is 89.60 (155 people), and that of Han people is only 10.40% (18 people). On the other hand, in low-risk areas, although the percentage of

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TABLE 3 The MANOVA analysis of risk perception between different ethnic groups.

Items	Indigenous people		Han people		F-value
	Mean	Sd	Mean	Sd	
Always worry about climate risk	4.159	0.908	4.343	0.914	2.143
It is predicted that typhoon or an earthquake will result in serious disasters	4.150	0.865	4.358	0.865	3.006
Climate disasters will get worse	4.107	0.882	4.298	0.835	2.505
The temperatures are getting hotter and hotter	4.120	0.868	4.328	0.746	3.179
The intensity of single rainfall will be much heavier	4.013	0.888	4.164	0.809	1.570
Where I live is getting more and more unsafe	4.000	0.895	4.194	0.783	2.578
Climate disasters might kill my family and me	4.077	0.823	4.134	0.694	0.263
Climate disasters will cause my property loss	4.090	0.791	4.209	0.664	1.257
Climate change has no impact on our generation	3.961	1.131	3.791	1.067	1.210
The environment where the future generations live will be affected by climate change	4.056	0.966	4.224	0.755	1.725

Pillai's Trace = 0.028, F-value = 0.841, p-value = 0.589

indigenous people is 61.42% (78 people), Han people have a significantly higher percentage of 38.58% (49 people). In terms of age distribution, 44.18% (76 people) of respondents living in high-risk areas are aged 50 and above, and 55.28% of them (96 people) are under 50 years old, but in low-risk areas, those aged 50 and above account for only 21.16% (27 people) of the respondents, while 78.84% (100 people) of them are under the age of 50. Regarding levels of education, 62.99% (80 people) of the respondents in low-risk areas had attained a degree from high schools, vocational schools or above, but the level of educational attainment for those in high-risk areas is relatively low, with a percentage of only 47.98% (83 people). As for occupation, 38.78% (66 people) of the respondents living in high-risk areas are engaged in agriculture, forestry, fishery and animal husbandry, compared with a percentage of only 7.87% (10 people) of those in low-risk areas where interviewees engaged in service industry versus students, retirees, or the unemployed account for 33.86% (43 people) and 41.73% (53 people) respectively, which is higher than those living in high-risk areas. In addition, in terms of income, it can be found that 78.95% (135 people) of the respondents in high-risk areas have an income of less than NT$ 40,000, but the income for 32.28% (41 people) and 18.90% (24people) in low-risk areas reaches NT$60,000 to NT$80,000 respectively.

Overall, respondents living in high-risk areas are more likely to be indigenous, older, less educated, engaged in agriculture, forestry, fishery, animal husbandry, with a low income, while it is the opposite case for those living in low-risk areas. The background differences among respondents across ethnic groups are found only in age, occupation and monthly family income. The age of the indigenous people slightly shows a U-shaped distribution with a majority of young and old people, most of whom are engaged in agriculture, forestry, fishery, animal husbandry and service industries, with a relatively low monthly income. Relative to that, there is a heavy concentration of the middle age group among the Hans whose occupations are mostly in industry, commerce, military, public education, or who are retired or unemployed with relatively high earnings.

3.1 Perceptions of and attitudes toward climate change

This study uses MANOVA analysis to explore the differences in perception of and attitudes toward climate change between two variables: ethnic groups and ethnic groups in different risk areas. From the results of one-way ANOVA, it can be seen that the average scores of each item on climate change perception and attitude among the indigenous and Han people are almost all higher than 4 points; that is, they mostly agree with the narrative content of the items. However, the average score of the negatively worded question "Climate change has no impact on my generation" is also higher than 3, with 3.961 points for the indigenous and 3.791 points for Han people. It is obvious that the impact of climate change has not been personally felt. However, in terms of statistical tests, there is no significant difference between ethnic groups.

This study continued to divide groups based on ethnicity and risk location, including the indigenous in high-risk areas (Group 1), Han people in high-risk areas (Group 2), the indigenous in low-risk areas (Group 3), and Han people in low-risk areas (Group 4). After grouping, it can be found that there are significant differences between the indigenous and Han people in different regions. In Table 4, there is no significant difference across the four groups only in the question "Climate change will have no impact on my generation," and the average scores are all above 3.7. This question is a reverse question, and most of the respondents checked the median value, indicating that one does not strongly agree with the description of this item. However, there are significant differences in average values of respondents' answers to the other questionnaire items and the differences vary with regions mainly. Taking question 1"Always worry about climate change" as an example, the average score of 4.705 for the indigenous living in low-risk areas is significantly higher than the 3.884 points (3 > 1) for the indigenous and 3.389 (3 > 2) for Han people living in high-risk areas. Besides, the average score of 4.694 for Han people in low-risk areas is also higher than that of the indigenous in high-risk areas (4 > 1) and Han people in high-risk areas (4 > 2). It shows that residents

TABLE 4 The MANOVA analysis of risk perception among different ethnic groups in various risk areas.

Items	IH(1)	HH(2)	IL (3)	HL (4)	F-value	Scheffé test
Always worry about climate risk	3.884 (0.932)	3.389 (1.037)	4.705 (0.537)	4.694 (0.548)	30.929***	3 > 1, 3 > 2 4 > 1, 4 > 2
It is predicted that typhoon or an earthquake will result in serious disasters	3.903 (0.866)	3.389 (0.641)	4.641 (0.624)	4.714 (0.577)	30.800***	3 > 1, 3 > 2, 4 > 1, 4 > 2
Climate disasters will get worse	3.890 (0.894)	3.556 (0.784)	4.539 (0.678)	4.571 (0.677)	19.264***	3 > 1, 3 > 2, 4 > 1, 4 > 2
The temperatures are getting hotter and hotter	3.936 (0.895)	3.778 (0.878)	4.487 (0.679)	4.531 (0.581)	13.377***	3 > 1, 3 > 2, 4 > 1, 4 > 2
The intensity of single rainfall will be much heavier	3.781 (0.928)	3.667 (0.907)	4.474 (0.575)	4.347 (0.694)	16.312***	3 > 1, 3 > 2, 4 > 1, 4 > 2
Where I live is getting more and more unsafe	3.819 (0.957)	3.444 (0.856)	4.359 (0.624)	4.469 (0.544)	15.433***	3 > 1, 3 > 2, 4 > 1, 4 > 2
Climate disasters might kill my family and me	3.942 (0.906)	3.500 (0.786)	4.346 (0.577)	4.367 (0.487)	10.518***	3 > 1, 3 > 2, 4 > 1, 4 > 2
Climate disasters will cause my property loss	3.994 (0.841)	3.722 (0.752)	4.282 (0.643)	4.388 (0.533)	6.547***	3 > 2, 4 > 1, 4 > 2
Climate change has no impact on our generation	3.871 (1.247)	3.944 (0.873)	4.141 (0.833)	3.735 (1.132)	1.577	
The environment where the future generations live will be affected by climate change	3.936 (1.097)	3.611 (0.979)	4.295 (0.561)	4.449 (0.503)	7.220***	3 > 1, 3 > 2, 4 > 1, 4 > 2

Pillai's Trace0.351, F-value = 3.830, p-value <0.001
Note 1: values given in parenthesis are percentage.
Note 2: IH = indigenous people in high risk area; HH = Han people in high risk area; IL = indigenous people in low risk area; IH = han people in low risk area.
Note 3: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

living in low-risk areas, regardless of their ethnicity, are more worried about the impact of climate risks than those in higher-risk areas.

There is no difference in perceptions of climate change if considering only the ethnicities between the indigenous and Han. However, if the risk levels of the residential areas enter the equation, locations will be the main factor generating differences. Moreover, the average score of residents in low-risk areas is mostly higher than 4 points than those residents with a score below 4 in high-risk areas. In view of this, residents in low-risk areas are more cautious about their perception and attitude towards climate change. They believe that the impact of climate risks will gradually expand, types of natural disasters will be more severe, places for living will become increasingly unsafe, and various property losses will also increase and even affect the next-generation.

3.2 Climate risk avoidance behavior

This study presents the climate risk avoidance behavior of different ethnic groups in Table 5. It is found that the average score of Han people in all question items is higher than 3 points and higher than that of the indigenous people. However, the aborigines score below 3 in average on two items: "My place of residence is absolutely safe," and "I will invest in greenhouse equipment," indicating that the aborigines still have safety concerns about the place where they live, and their attitude towards investing in greenhouse equipment is relatively conservative. Given that, this research further used multivariable variance analysis to explore whether there are differences in perception between the two ethnic groups. The results of the study show that the average scores of 9 out of 10 items of the Han people are significantly higher than those of the indigenous peoples, except on the item "Owned fields cannot be replanted in a short time after destruction," indicating that regardless of ethnicity, people believe that agricultural production affected by climate change cannot be restored in a short time. However, the results of multivariate statistical analysis find that the Han people are more affirmative about risk avoidance than the indigenous people. Be it a choice of a place for living or farming, they would stay farther away from rivers and landslide areas and they will be are more concerned about diversifying risks in terms of farming behaviors, such as diversifying the locations where crops are grown, choosing different types of crops, and being more willing to invest in greenhouse equipment.

In Table 6, the results of this study show that there are significant differences in the viewpoints between the indigenous and Han people, which is the same as stated in previous studies. However, what differentiate this research is the exploration on whether the two ethnic groups living in areas of different risks differ in their avoidance behaviors. The results grouped in 4 according to risk locations and ethnic groups reveal that the four groups do have differences on each item in avoidance behaviors, and the differences are almost in accord. The results are shown in Table 7. To all avoidance behavior questions, the responses from the indigenous and Han people of different regions differ. The average number of residents living in low-risk areas is higher than that of residents

TABLE 5 The MANOVA analysis of avoidance behavior between different ethnic groups.

Items	Indigenous people		Han people		F-value
	Mean	Sd	Mean	Sd	
My home is far away from the river	3.401	1.609	4.049	1.482	8.446**
Farming area is far away from the river	3.202	1.496	3.881	1.462	10.819***
My home is far away from the landslide area	3.103	1.511	3.761	7.587	9.656**
Farming area is far away from the landslide area	3.047	1.483	3.657	1.533	8.655**
Where I live is absolutely safe	2.768	1.586	3.731	1.523	19.526***
My farming areas are located in various places	3.232	1.289	3.657	1.343	5.550*
I will practice the crop diversification concept	3.262	1.162	3.791	1.175	10.748**
The goal of maximizing the harvest amount is not in my concern	3.485	1.022	3.836	0.947	6.333*
If my farming area is damaged, it's impossible to be recovered its function in a short time	4.000	0.965	4.119	0.749	0.874
I will invest in greenhouse culture to ensure stable agricultural production	2.489	1.598	3.716	1.324	32.990***

Pillai's Trace = 0.121, F-value = 3.976, p-value <0.001
Note 1: *p < 0.05, **p < 0.01, ***p < 0.001.

TABLE 6 The MANOVA analysis of avoidance behavior among different ethnic groups in various risk areas.

Items	IH(1)	HH(2)	IL (3)	HL (4)	F-value	Scheffé test
My home is far away from the river	2.781 (1.601)	2.056 (1.392)	4.654 (0.554)	4.776 (0.550)	63.687***	3 > 1, 3 > 2 4 > 1, 4 > 2
Farming area is far away from the river	2.516 (1.321)	1.944 (1.392)	4.564 (0.656)	4.592 (0.574)	93.941***	3 > 1, 3 > 2 4 > 1, 4 > 2
My home is far away from the landslide area	2.368 (1.243)	1.556 (0.984)	4.564 (0.731)	4.571 (0.791)	118.943***	1 > 2, 3 > 1, 3 > 2, 4 > 1, 4 > 2
Farming area is far away from the landslide area	2.336 (1.213)	1.556 (0.984)	4.462 (0.801)	4.429 (0.791)	110.954***	1 > 2, 3 > 1, 3 > 2 4 > 1, 4 > 2
Where I live is absolutely safe	1.923 (1.165)	1.611 (1.145)	4.449 (0.750)	4.510 (0.649)	163.958***	3 > 1, 3 > 2 4 > 1, 4 > 2
My farming areas are located in various places	2.626 (1.082)	1.889 (1.023)	4.436 (0.676)	4.306 (0.713)	98.154***	1 > 2, 3 > 1, 3 > 2 4 > 1, 4 > 2
I will practice the crop diversification concept	2.755 (1.021)	2.222 (0.878)	4.269 (0.658)	4.367 (0.602)	85.317***	3 > 1, 3 > 2 4 > 1, 4 > 2
The goal of maximizing the harvest amount is not in my concern	3.097 (0.945)	2.722 (0.826)	4.256 (0.623)	4.245 (0.596)	52.355***	3 > 1, 3 > 2 4 > 1, 4 > 2
If my farming area is damaged, it's impossible to be recover its function in a short time	3.807 (1.045)	3.500 (0.786)	4.385 (0.629)	4.347 (0.597)	12.005***	3 > 1, 3 > 2 4 > 1, 4 > 2
I will invest in greenhouse culture to ensure stable agricultural production	1.568 (1.038)	2.000 (1.188)	4.321 (0.655)	4.347 (0.631)	221.707***	3 > 1, 3 > 2 4 > 1, 4 > 2

Pillai's Trace = 0.840, F-value = 11.236, p-value <0.001
Note 1: values given in parenthesis are percentage.
Note 2: IH = indigenous people in high risk area; HH = Han people in high risk area; IL = indigenous people in low risk area; IH = han people in low risk area.
Note 3: *p < 0.05, **p < 0.01, ***p < 0.001.

living in high-risk areas, and there is a big discrepancy in the averages. The average number of the former is 4 points or above, while the latter scores mostly below 3 points, or even below 2 points. Yet, if we observe the mean values of each item on the avoidance behavior of the indigenous and Han residents in areas of different risks, we can find that the average number of the indigenous people

TABLE 7 The MANOVA analysis of adaption strategy between different ethnic groups.

Items	Indigenous people		Han people		F-value
	Mean	Sd	Mean	Sd	
I know how to select a safe place to live	3.811	0.885	4.328	0.927	17.395***
I know how to select a safeplace to farm	3.803	0.853	4.388	0.834	24.744***
Our ancestors taught us the environmental knowledge	3.451	1.121	4.328	0.960	33.894***
I will practice proper disaster prevention work after observing the surrounding environment	3.803	0.853	4.358	0.829	22.338***
My crop selection is based on the suggestions from Farmers' Association	3.854	0.949	4.149	0.892	5.166*
My crop selection depends on current market trend?	3.880	0.853	4.194	0.857	7.051**
I will select climate-adapted crops	3.940	0.807	4.239	0.799	7.165**
It's hard for me to accept the property damage caused by disasters	4.052	0.899	4.254	0.785	2.781
I will take out a lot of insurance	2.807	1.500	3.955	1.224	32.920***
I will apply for the agricultural disaster subsidy	4.103	0.990	4.224	0.918	0.800

Pillai's Trace = 0.131,F-value = 4.366,p-value <0.001.
Note 1: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

in the high-risk area is higher than that of the Han people, but in the low-risk area, the average number of the Han people is higher than that of the aboriginal people. Regarding the three items on "residing far away from landslide areas," "farming locations far away from landslide areas," and "locations for field scattering," there are significant differences in the concepts of residents in high- and low-risk areas. In particular, the indigenous and the Han people living in high-risk areas display differences in their concepts. The aborigines in high-risk areas are more likely to choose to live and farm away from landslide areas than the Han people, and they will also cultivate crops in more dispersed locations.

On the whole, regional risks and differences between the indigenous and Han people manifest different avoidance behaviors. Respondents living in Fengqiu Village and Shang'an Village, which bear lower risk and vulnerability, are consistent with the reality in their descriptions of their residence and farming land far away from rivers and landslides. On the contrary, the interviewees living in Fengqiu Village and Shang'an Village with higher risk and vulnerability are inevitably exposed to hazards. On the other hand, regarding scattered crop farming locations and small-scale diversified cultivation, high-risk locations may be limited by considerations of arable areas, yields, and market accesses, making it impossible to engage in farming activities from the perspective of risk diversification. Conversely, low-risk areas in the middle and lower reaches have more cultivated land where there are other non-cash crops in addition to the main crops. All the questions in this part reflect the actual situation of farming practices in mountain villages that are limited by geographical location. There is an exception to this part, that is, the acceptance of the concept "will invest in greenhouse equipment" in high-risk areas is much lower than in low-risk areas. Providing the high cost of greenhouse equipment investment, when the disaster scale is small, greenhouse equipment can indeed protect agricultural crops from losses; but when the disaster scale increases and intensifies, investing in greenhouse equipment will undoubtedly result in greater economic losses and longer recovery period. Therefore, high-risk areas are more likely to avoid this risk, which is in line with theoretical expectations.

3.3 Climate disaster knowledge and adaptation strategies

In terms of the analysis of the differences in knowledge and adaptation strategies between the aboriginal people and Han people about climate disasters, Table 7 shows that the average score of the Han people on nine items is higher than 4 points except a lower 3.955 on the item "I will take out a lot of insurance". Nevertheless, the average score of Han people in all questions is higher than that of aborigines. In fact, the average score of Aboriginal people on most questions is close to 4 points, except a low 2.807 on the item "I will take out a lot of insurance", implying that Aboriginal people are less likely to agree with this avoidance behavior. When using multivariate analysis to analyze the differences in adaptation strategies between ethnic groups, we can find that there are significant differences in 8 items. For example, compared with the aborigines, the Han people believe that they know better how to choose safe places to live and farm. They also believe that their ancestors have taught them environmental knowledge, so they will take appropriate disaster prevention measures. The Han people are also relatively willing to take in external information, such as listening to farmers' association suggestions for planting crops, or observing market conditions to decide on what crops to plant, and choosing appropriate crop types. In terms of insurance purchase, the acceptance rate of Han people is also significantly higher than that of the indigenous people. However, regardless of the ethnicities, there is no difference in perception on the two items, "Difficult to accept property losses caused by disasters" and "Willing to apply for agricultural damage subsidies," and the average scores are all higher than 4 points, which means that regardless of ethnic

TABLE 8 The MANOVA analysis of adaption strategy among different ethnic groups in various risk areas.

Items	IH(1)	HH(2)	IL (3)	HL (4)	F-value	Scheffé test
I know how to select a safe place to live	3.400 (0.744)	3.056 (0.539)	4.628 (0.486)	4.796 (0.499)	108.297***	3 > 1, 3 > 2 4 > 1, 4 > 2
I know how to select a safe place to farm	3.426 (0.711)	3.222 (0.428)	4.551 (0.573)	4.816 (0.441)	99.833***	3 > 1, 3 > 2 4 > 1, 4 > 2
Our ancestors taught us the environmental knowledge	2.929 (0.934)	3.111 (0.900)	4.487 (0.639)	4.776 (0.468)	105.166***	3 > 1, 3 > 2 4 > 1, 4 > 2
I will practice proper disaster prevention work after observing the surrounding environment	3.445 (0.722)	3.278 (0.575)	4.513 (0.619)	4.755 (0.480)	81.109***	3 > 1, 3 > 2 4 > 1, 4 > 2
My crop selection is based on the suggestions from Farmers' Association	3.594 (0.938)	3.222 (0.878)	4.372 (0.740)	4.490 (0.617)	26.966***	3 > 1, 3 > 2 4 > 1, 4 > 2
My crop selection depends on the current market trend	3.587 (0.812)	3.333 (0.840)	4.462 (0.596)	4.510 (0.617)	39.073***	3 > 1, 3 > 2 4 > 1, 4 > 2
I will select climate-adapted crops	3.710 (0.764)	3.389 (0.608)	4.397 (0.690)	4.551 (0.614)	30.689***	3 > 1, 3 > 2 4 > 1,4 > 2
It's hard for me to accept the property damage caused by disasters	3.884 (0.946)	3.722 (0.845)	4.385 (0.688)	4.449 (0.647)	10.474***	3 > 1, 3 > 2 4 > 1, 4 > 2
I will take out a lot of insurance	2.013 (1.122)	2.556 (1.338)	4.385 (0.688)	4.469 (0.649)	143.467***	3 > 1, 3 > 2 4 > 1, 4 > 2
I will apply for the agricultural disaster subsidy	3.916 (1.081)	3.389 (1.195)	4.474 (0.639)	4.531 (0.544)	13.463***	3 > 1, 3 > 2 4 > 1, 4 > 2

Pillai's Trace = 0.800,F-value = 10.518,p-value <0.001
Note 1: values given in parenthesis are percentage.
Note 2: IH = indigenous people in high risk area; HH = Han people in high risk area; IL = indigenous people in low risk area; IH = han people in low risk area.
Note 3: *p < 0.05, **p < 0.01, ***p < 0.001.

groups, neither can accept property losses caused by climate change, and will all apply for agricultural damage subsidies.

If the aspects of climate disaster knowledge and adaptation strategies are regarded as the respondents' own knowledge, and climate risk avoidance behavior is regarded as their actual actions, then comparing the items with similar concepts in Tables 6, 8, it can be found that regardless of the aboriginal or Han people, their average values in the climate risk avoidance behavior aspects are lower than those in the climate disaster knowledge and adaptation strategies aspects. For example, both believe that they know how to choose a safe place to live and farm, with an average score of about 3.8 points. However, when answering questions about whether the place they have chosen to live or farm is safe, they only gave scores of about 3.4 and 3.2 points. In other words, although the indigenous and Han residents in mountain villages may have better risk awareness, they may actually be limited by objective conditions such as the real economy practices or environment. As a result, rather than choosing ideal locations, they could only yield their choices of residences, farming locations or crops to current situations.

This study then compared the differences in climate disaster knowledge and adaptation strategies between the indigenous and Han residents in high- and low-risk areas. The results are presented in Table 8. The research results show that of all items, the awareness of aborigines or of Han people in low-risk areas in this aspect is significantly higher than their counterparts in high-risk areas. Taking the question "Know how to choose a safe location to live in" as an example, the average score of the indigenous people living in low-risk areas is 4.628, notably higher than the score of 3.400 (3 > 1) of the indigenous and the Han people's 3.056 (3 > 2) in high-risk areas. The average score of the Han people in low-risk areas is 4.796, which is also remarkably higher than both the indigenous and Han people in high-risk areas. Although the indigenous and Han people in low-risk areas obviously have higher awareness of risk adaptation strategies than those in high-risk areas, the indigenous and Han people in high-risk areas also score 3 points or more in their awareness of these items. However, on the question "will buy a lot of insurance," the average cognitive scores of the indigenous and Han people in high-risk areas drop below 3 points, to 2.013 points and 2.556 points respectively, while numbers are as high as 4.385 points and 4.469 points among their counterparts living low-risk areas. If buying insurance is regarded as an investment behavior that requires paying for costs, the indigenous and Han residents in high-risk areas may also be limited by factors such as income and stereotypes about insurance, and be less willing to choose this risk adaptation strategy.

In terms of climate disaster knowledge and adaptation strategies, Han people have evidently higher perception than the indigenous people. However, if regional risk factors are taken into consideration, it can be found that residents in different places also have cognitive differences in risk adaptation strategies. The indigenous and Han ethnic groups in low-risk areas obviously believe that they know better how to choose safe places to live and farm, and are better at taking appropriate disaster prevention measures, listening to expert advice, and choose suitable locations and crops for cultivation. The adaptation perception of these two

TABLE 9 The MANOVA analysis of three dimensions among different SES groups in various risk areas.

Group	Dimension	Pillai's Lambda	F-value
DR (2 groups)*SEX (2 groups) (total = 4 groups)	Cognitive dimension	0.354	3.801***
	Behavioral dimension	0.803	10.375***
	Adaptive dimension	0.768	9.777***
DR (2 groups)*AGE (3 groups)	Cognitive dimension	0.539	1.836***
	Behavioral dimension	0.959	3.435***
	Adaptive dimension	0.937	3.345***
DR (2 groups)*EDU (5 groups) (total = 6 groups)	Cognitive dimension	0.413	2.601***
	Behavioral dimension	0.864	6.038***
	Adaptive dimension	0.851	5.930***
DR (2 groups)*INC.(4 groups) (total = 8 groups)	Cognitive dimension	0.426	1.861***
	Behavioral dimension	0.879	4.121***
	Adaptive dimension	0.912	4.298***
DR (2 groups)*OCU(4 groups) (total = 8 groups)	Cognitive dimension	0.419	1.835***
	Behavioral dimension	0.896	4.225***
	Adaptive dimension	0.895	4.221***

Note 1: DR, degree of the risk in this area; SEX, sexual; Age, age; EDU, education; INC,. income; OCU, occupation.
Note 2: *p < 0.05, **p < 0.01, ***p < 0.001.

ethnic groups in low-risk areas is actually reflected in the actual risk avoidance behavior in Table 7. It is worth noting that the average score of the aboriginal people in high-risk areas for the question "Ancestors have taught us environmental knowledge" is only 2.929, which is slightly different from what past research suggested that the ecological knowledge were passed down from generation to generation. Yet, the average score of indigenous people in low-risk areas is as high as 4.487 points for the same question item. What's more, in all items, the average number of indigenous people in low-risk areas is higher than that in high-risk areas. In view of this, it is recommended to add factors such as regional environment scales in addition to the commonly adopted dichotomy method in the past which was insufficient to distinguish various types of perceptions and behaviors of in detail among the residents in mountain villages.

3.4 Differences in various aspects between residents in high- and low-risk areas with different backgrounds

As stated in the analysis above, the indigenous people in high-risk areas seem to have lower risk perception and avoidance behaviors than the other three groups. In order to understand whether this response is affected by other background factors, this study adopted socio-economic variables such as gender, education level, income and occupation in response to three major aspects of climate change and examined them one by one. After individual application of MANOVA analysis, it was confirmed that socio-economic variables did not cause differences in responses to various aspects of climate change. Even if there were differences, they were only significantly different in a very small number of items.

Risk areas were then included to examine differences in responses by gender, education, income and occupation, and were divided into four groups (2*2 = 4), namely, men in high-risk areas, women in high-risk areas, and men in low-risk areas as well as women in low-risk areas. The same grouping method was applied to education level, income and occupation as well. The results are presented in Table 9. Table 9 clearly shows that groups with different regional risks combined with different backgrounds show significant differences in the three major aspects of climate change issues. Regardless of gender, education level, income and occupation, as long as residents live in low-risk areas, then its average values for most climate change issues are notably higher than those of residents living in high-risk areas. This confirms that the regional environmental scale is an important factor affecting various perceptions and behaviors of mountain village residents.

4 Conclusion

Most studies on climate change analyze key factors in disaster prevention from a macroscopic perspective, such as socio-economic demographic data at the county or township level. However, the results of these macro data analyses cannot be applied to micro-scale management at the village level. Therefore, this study aims to explore the perceptions and actions of residents living in mountain villages with different risk levels in response to climate change. A total of 300 valid questionnaires were collected from four villages in Nantou mountain and analyzed by multivariate analysis of variation analysis. The results of this research find that Han people perform significantly better than indigenous people in avoidance behavior and adaptation strategies due to their better socio-economic conditions. When further distinguishing by risk levels, significant differences emerge among four groups: indigenous in high-risk areas, Han in high-risk areas, indigenous in low-risk areas, and Han in low-risk areas. Indigenous and Han residents in low-risk areas outperform those in high-risk areas in climate risk perception, avoidance behavior, and adaptation strategies. Additionally, respondents from different backgrounds (gender, age, income, occupation) in low-risk areas fare better in these aspects than those in high-risk areas. Notably, residents in high-risk areas exhibit lower actual avoidance behavior than their perceived behavior, possibly due to limitations in occupation, education, income, or available space.

In conclusion, this study highlights significant differences in ethnic distribution and geographical features within small-scale villages in the upper Shuili stream area. Indigenous people in high-risk areas, traditionally considered knowledgeable about mountains and forests, show lower risk perception, avoidance behavior, and adaptation strategies. Cultural assimilation among neighboring villages may also affect differences between residents in mountainous and shallow mountainous areas. Future research should compare towns and villages in different geographical locations for a broader understanding of population characteristics. This study offers two key recommendations. First, we suggest that future researchers collect additional data to further explore the differences in climate change response strategies between the Han and indigenous peoples, thereby enhancing the comprehensiveness of related research. Second, we recommend that when the government or research institutes address climate change disaster prevention in mountainous areas, they consider planning on a village-by-village basis to ensure more effective and locally tailored strategies.

Data availability statement

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

Author contributions

Y-TC: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. J-CL: Conceptualization, Data curation, Methodology, Supervision, Writing – review and editing. S-FW: Data curation, Methodology, Supervision, Validation, Writing – review and editing. P-JW: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing.

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