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Local Residents' Social-Ecological Adaptability of the Qilian Mountain National Park Pilot, Northwestern China

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Abstract: Protected areas are critical for biodiversity conservation and ecosystem services. In the last few years, there has been growing recognition of the role of indigenous peoples and local communities in the management of government designated protected areas, and thus their perceptions and adaptability were paid much attention. Drawing on a survey of 487 residents in the Qilian Mountain National Park Pilot of Northwestern China, this study used the adaptive analysis framework to study the adaptability of local residents. The main contribution of this paper is to select a typical social-ecological system to study the adaptability of local residents, and using Elinor Ostrom's Social-Ecological System framework to analyze the adaptability mechanism. The results show that different types of residents had different adaptability to environmental change. People whose income mainly depends on work salary with a small part of herding have the highest level of adaptability, while people whose income mostly comes from farming with a small part of herding have the lowest level. This result is related to people's living location, as people living in the core zone and buffer zone of the reserve mainly earned from grazing, and people living in the experimental zone and peripheral zone earned mainly from outside work. Moreover, people living in the core zone and buffer zone are mostly elders and ethnic groups, while people in the experimental zone and buffer zone are Han people. To improve management effectiveness and to avoid conflict between local residents and managers, this paper suggests that more attention should be paid to these who have lived for a long time in the core zone and buffer zone. They are the most vulnerable groups and show low adaptability in almost all domains. For the long run, education quality should be improved to decrease the population in the reserve.

Keywords: adaptability; residents; perception; Qilian Mountain National Park Pilot; social-ecological system

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1. Introduction

Protected areas (PAs) are one of the most important conservation tools for protecting biodiversity and ecosystem services [1–4]. To date, PA coverage has reached over 15% of the global land area [5,6]. Despite this extensive coverage, it is widely acknowledged that PAs are being increasingly influenced by global forces of economic development and socio-political change [7–9]. Therefore, there is a need to better understand the complex interactions between humans and protected areas [10–13].

Adaptability is a notion that was originally used in ecology to emphasize that species can change their own state and procreate species to adapt to changing environments [14–16]. Then, the application of adaptability expanded from biophysics to sociology, like how a social system adjusts its own behavior to the natural environment [17]. It was later also applied to the fields of climate change and natural disasters [18]. In these fields, adaptability was adjusted by natural ecosystems or human systems in response to actual or expected climate change and natural disasters, emphasizing risk recognition, adjustment and management [19,20]. Around the year 2000, adaptability was widely applied as an important

attribute of social-ecological systems (SESs) [21–24]. In the field of SESs, adaptability referred to the capacity of actors to adjust their behaviors in response to external uncertainties and disturbances [25]. Adaptability was often associated with resilience [21–23,26,27]. It was a capacity of actors in the SES to influence resilience, and essentially to manage it [22]. At present, scholars take "SES" as the main research object, and it was an important trend of sustainable development and global change to study the adaptability to external disturbance and the adaptability mechanism. The research scale of SES adaptability mainly focused on national, regional and community levels [28–30]. At the community level, there was no lack of studies integrating livelihood capital from the Sustainable Livelihood Framework into the index system of adaptability evaluation [31,32]. However, the five dimensions of the Sustainable Livelihood Framework (physical, nature, social, financial and human capital) mainly represent the society, economy, and the ecology, which are the three pillars of SESs. Most studies did not explore the comprehensive impact of external policies and internal psychology and culture on livelihood system, and also separated the interaction between subsystems, although there were many studies that have introduced and modified the adaptive analysis framework proposed by Smit et al. (namely, adaptation to what, who or what adapts, and how does adaptation occur?) [25,33]. However, there were few studies that comprehensively constructed an analysis framework of SESs, sustainable livelihood, residents' behavior and adaptability. Therefore, it is necessary to construct an analysis framework of residents' adaptability for SESs.

The Qilian Mountain Nature Reserve, which is located in Gansu Province, western China, recently became a focus of attention due to its ineffective management. To improve the management, the reserve was then designated to be a pilot national park, and its name thereby was changed into Qilian Mountain National Park Pilot (QMNPP). However, the notion of a national park is relatively new in China. Considering that there are still many people living in the reserve and it is impossible to move all of them out, a better understanding of residents' perceptions and adaptations will benefit synergetic development of nature conservation and human welfare for the newly established national park. This study constructed an analysis framework of residents' adaptability in the QMNPP, and comprehensively evaluated the adaptability of farmers from different types and regional locations. Then, the impact factors and adaptability mechanism were also analyzed. Finally, we put forward suggestions to improve the adaptability of residents and enhance management effectiveness. The innovations of this article include the following: (1) Combining the Sustainable Livelihood Framework with the existing adaptability analysis framework to construct an analysis framework of residents' adaptability in the QMNPP, which improved the adaptability index system to some extent and provided reference for the adaptability study of residents in other protected areas; and (2) Ostrom's Social-Ecological System Framework (SESF) was used to analyze the adaptability mechanism, systematically analyze the causes of residents' adaptive behavior and the interaction within the system, and deepen the analysis of impact factors of adaptability.

2. Study Area

The QMNPP is part of Qilian Mountain range on the border of Qinghai and Gansu provinces, northwest China (Figure 1). It is a natural germplasm bank of alpine creatures and an important ecological corridor. It is protected for Picea crassifolia, Cypress chinensis, cranes and other organisms. However, snow leopard, a national first-class key protected animal, has been frequently captured by camera recently. The QMNPP is also designated as a national key water conservation forest area, a national natural forest protection project area, a national key ecological public welfare forest, and so on. The landscape covers glaciers, forests, grasslands, deserts, etc., and is a priority area for biodiversity conservation in China. The snow and glaciers on the Qilian Mountain provide precious water to more than 5 million people in the Hexi Corridor, which is located at the northern foot of the Qilian Mountain and characterized by its arid climate. Therefore, the Qilian Mountain is

also called the Mother Mountain of the Hexi Corridor, making its protection much more meaningful.

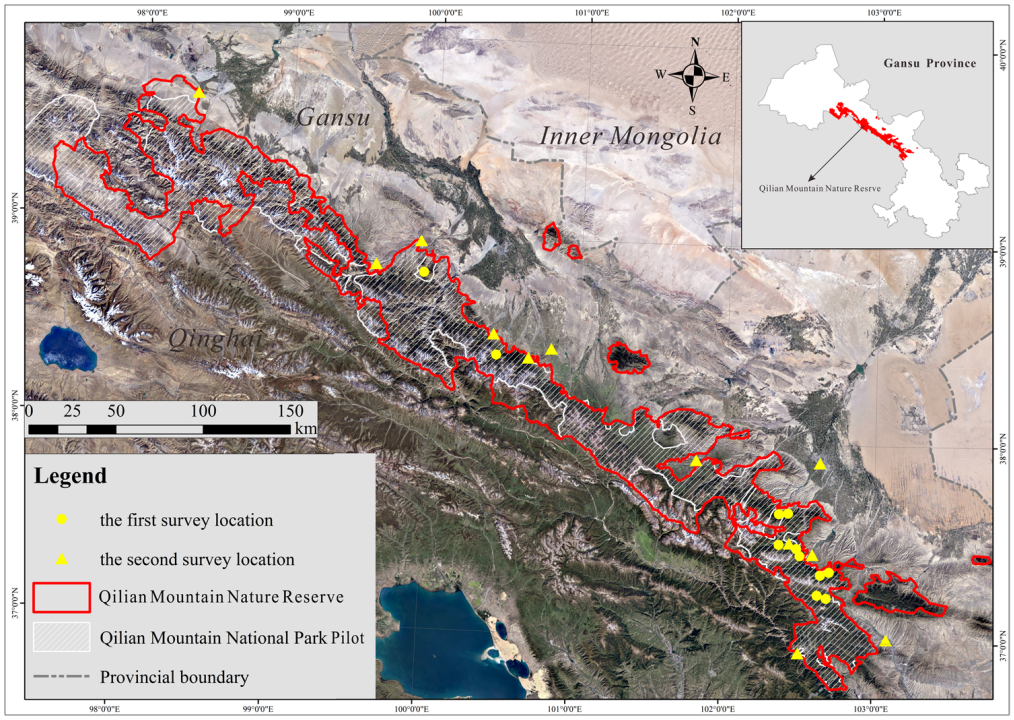

Figure 1. Study area.

People living inside the Qilian Mountain area have a very long history. However, intensive resource use began in the 1960s, when logging became an important industry for the area. Then, mining and hydropower infrastructures followed, and the number of livestock has rapidly increased in the 1980s and 1990s. As a result, serious grassland degradation was detected in the late 1990s. Therefore, restoration of grassland for this area has been paid much attention from the early 2000s. In 2015, a public warning was given to local officers by the State Forestry Administration and the Ministry of the Environment of China, and human activities, such as illegal mining, unauthorized construction of hydropower facilities, excessive waste discharge and polluting emissions by local factories, are main issues that existed in the reserve. However, things changed little in the next two years. Then, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council gave a briefing on the destruction of the ecological environment in the reserve in July 2017. Nevertheless, the operation of mining and hydropower stations have not been stopped until 2018. In particular, tourism has greatly developed from the early 2000s.

To sum up, the QMNPP has rich natural resources and a long history of human activities, and is a complex adaptive system composed of ecological subsystems and social subsystems [34,35]. In addition to the typical natural ecosystem, its environmental problems are also typical. Furthermore, human utilization of natural resources and strong dependence on resources are typical. In 2017, it was identified as one of the pilot projects of national parks, and its experience can be replicated and promoted as an example. Based on this, we selected the QMNPP as a typical social-ecological system, and there is a need to clarify the adaptability of local residents.

3. Data and Methods

3.1. Data Source

In-depth interviews and questionnaires were conducted to collect data for this paper. The survey was conducted in September 2018 and October 2020. Considering the vast territory and intra-regional diversities of the QMNPP, and residents live in a scattered distribution, 10 protection stations and 2 towns were chosen as our survey destinations (Figure 1). Questionnaires were distributed randomly by government workers and protection station managers to the local residents. At the same time, we verified the credibility of the questionnaire results through in-depth interviews. A total of 513 questionnaires were sent out; questionnaires with incomplete information and inconsistent answers were deleted, and 487 valid questionnaires were recovered. Cronbach's α was 0.749 (>0.7), indicating that the data availability is good. Although the number of questionnaires was relatively small, it was found to be well-representative after comparison with the statistical data. Among respondents, the sample Tibetan population accounted for 27.93% of the total population, 11.91% of the total population had high school education, 24.85% had junior middle school education, and 30.39% had primary school education, which was approximately the same as the local statistical yearbook (in which the Tibetan population accounted for 26.27% of the total population and the Han was 42.5%, 10.22% of the total population had high school education, 22.65% had junior middle school education, and 36.79% had primary school education).

The survey content included three sections: (i) Social-demographic characteristics of respondents (i.e., age, gender, educational degree, location of the functional zone, household income, health, labor force); (ii) respondents' knowledge, satisfaction and implementation of legal policies in the QMNPP (the legal policies including "Returning the grain plots to forestry and grass", "Fodder–livestock balance system", "Eco-migration", "Eco-compensation", etc.); (iii) residents' perception of ecological, economic and social aspects in the QMNPP (i.e., the attitudes towards natural environment, economic source, economic income, infrastructure and ethnic culture). Questionnaire indicators were assigned by a five-point Likert scale.

3.2. Conceptual Analysis Model

The adaptive analysis framework constructed by Smit et al. (1999) was adopted in this paper [25]. It is a commonly used conceptual framework for adaptive analysis [33]. In the framework, the following aspects were considered (Figure 2): Adaptation to what? Who/What adapts? How does adaption occur? It proposes a framework to promote consistency and rigor in the use of concepts and terms for adaptability. This framework provides a structure for improving the science of adaptability and its adaptability to disturbance [25,26]. In addition, it also gave us the logic that we can study adaptation scientifically. Through this analytical framework, it is beneficial to further clarify the three core elements: adaptation to what, who or what adapts, and how does adaptation occur. This paper focuses on the local residents' adaptability, which is relatively simple in structure and complexity compared with regional systems, but requires more detailed and in-depth analysis. This framework can help us solve this problem. Therefore, this paper uses Smit et al.'s adaptive analysis framework to explore residents' adaptability to the changing environment.

In this paper, "Adaptation to what?" is the disturbance of the changing environment. Environmental changes will have risk and opportunity disturbance in the regional SES. "Who/What adapts?" refers to residents' adaptability to the changing environment in the QMNPP, including the adaptability of residents to policies, economy, ecology, society, culture and psychology. "How does adaption occur?" is the behavior response of residents, which is mainly in cognition, adaptive state, impact factors and mechanism of adaptability.

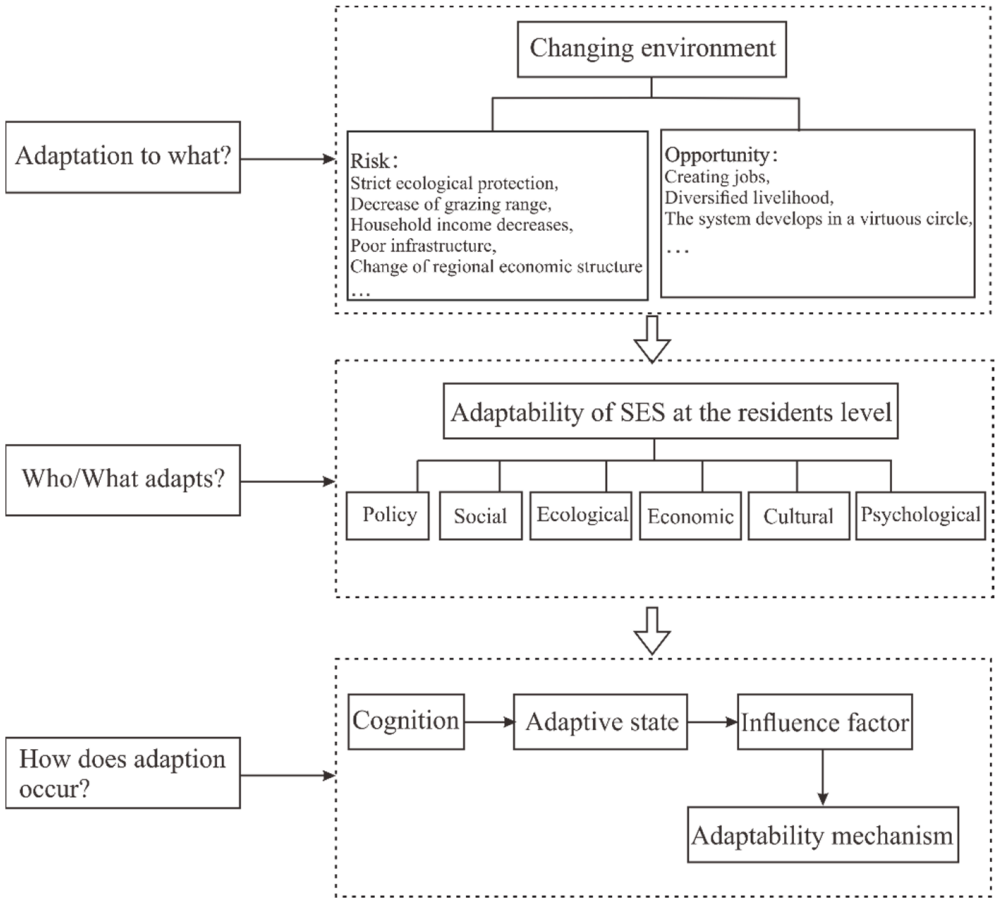

Figure 2. Analysis framework of residents' adaptability in the QMNPP (adopted from Smit et al. (1999) [25]).

3.3. Index System

Research of adaptability analysis methods usually adopts the Sustainable Livelihoods Framework [36,37], which examines residents' ability or capital to improve their quality of life and adaptability when they face natural disasters (such as drought, tsunamis, landslides), market competition, and system changes such as uncertain and changing environments. However, only using the Sustainable Livelihoods Framework to measure the adaptability of residents cannot reflect the integrity of SESs. The Sustainable Livelihood Framework [38–41] and Wu et al.'s (2018) [42] research were referred to build the indicator system. The analysis framework of residents' adaptability in this paper combines the Sustainable Livelihood Framework with the existing indicator system for adaptability evaluation, and adds the policy, culture and psychological dimensions as the "Who/What adapts?" part. Then, these indicators are classified into six domains, namely policy adaptability, social adaptability, ecological adaptability, economic adaptability, cultural adaptability and psychological adaptability. According to the characteristics of the QMNPP and availability of data, the index system was improved. For example, physical, social and financial capital of livelihood capital were integrated into the economic adaptability domain, and human and social capital were brought into the social adaptability domain. Furthermore, on the basis of the index system in Wu et al., the infrastructure was moved to the social domain, and indicators such as education, physical health and labor force were added. There were also many other such improvements.

Next, the Analytic Hierarchy Process (AHP) and the Expert Scoring method were used to weight the six domains. Eight experts including local managers, herdsmen who live in the park and scholars in ecology, sociology and geography were invited to score the indicators. The detailed steps were as follows: First, the eight experts were asked to score the six domains without communication, using the 1–5 scale method. Second, the scores of the eight experts were averaged to obtain the judgment matrix. Third, the matrix was analyzed by AHP, with weight calculation and a consistency test. The consistency of the weights was tested and the CR = 0.065 (<0.1), showing that the judgment matrix meets the consistency test. Finally, six domains of weights (W_i) were obtained (Table 1).

The index of measure layer was calculated via the entropy method. The result of the entropy method is objective. The detailed steps were as follows:

First, standard processing of data. All variables were normalized to a scale of 0–1, so they could be combined and compared.

Second, the specific gravity (f_{ij}) after dimensionless treatment was calculated. The formula is:

$$f_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}} \quad (1)$$

In the formula, x'_{ij} represents the normalized value of the jth term of the ith domain.

Third, we calculated the entropy value (e_j) and avail value (d_j) of the jth term, and the formula is as follows:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} f_{ij} \ln f_{ij} \quad (2)$$

$$d_j = 1 - e_j \quad (3)$$

Finally, we calculated the weight of item j's index (w_{ij}), and the calculation formula is as follows:

$$w_{ij} = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (4)$$

The final results are shown in Table 1.

Table 1. Adaptability index values of residents in the QMNPP. The policies included the following: "Returning the grain plots to forestry and grass", "Fodder–livestock balance system", "Eco-migration", "Eco-compensation", etc. B3 = Labor force ÷ total number of family. B4 = Number of high school or above ÷ total number of family. D3 = 5 ≥ 70,000; 4 = 50,000–70,000; 3 = 30,000–50,000; 2 = 10,000–30,000; 1 ≤ 10,000. Natural assets owned by households include the number of cattle and sheep, grassland area and so on. D5 = Productive consumption ÷ total annual consumption of a family.

Domain (i)	W_i	Measure (x_{ij})	w_{ij}
Policy adaptability	0.25552	A1 Knowledge	0.3636
		A2 Satisfaction	0.3158
		A3 Implementation	0.3206
Social adaptability	0.17083	B1 Social network	0.0270
		B2 Infrastructure	0.0496
		B3 Proportion of household labor force	0.1749
		B4 Education	0.2543
		B5 Physical health	0.4941
Ecological adaptability	0.10227	C1 knowledge of social-ecological system	0.5281
		C2 Ecological awareness	0.4719

Table 1. *Cont.*

Domain (i)	W_i	Measure (x_{ij})	w_{ij}
Economic adaptability	0.24628	D1 Satisfaction of income	0.2425
		D2 Livelihood diversity	0.2941
		D3 household income (¥)	0.2695
		D4 Natural assets	0.0733
		D5 Proportion of consumption	0.1206
Cultural adaptability	0.09522	E1 Ethnic costume	0.1898
		E2 Diet custom	0.1130
		E3 Ethnic languages	0.2781
		E4 Ethnic music and dance	0.2743
		E5 Traditional festival	0.1448
Psychological adaptability	0.12987	F1 Acceptance of external culture	0.3941
		F2 Family resilience	0.4366
		F3 Acceptance of change	0.1692

3.4. Adaptability Assessment Model

The Comprehensive Evaluation of the Residents' Adaptability Index (*RAI*) in the QMNPP was measured through the linear weighed method. The model is as follows:

$$RAI = \sum_{j=1}^{6} W_i F_{ti} \quad (5)$$

$$F_{ti} = \sum_{i=1}^{m} w_{ij} x'_{ij} \quad (6)$$

In the formula, W_i is the weight of the ith domain layer, and *RAI* is the comprehensive evaluation of adaptability index of measure j under domain i. *RAI* was then divided into four grades [43,44]; they are extremely low adaptability ($0.00 \leq RAI \leq 0.25$), low adaptability ($0.26 \leq RAI \leq 0.50$), high adaptability ($0.51 \leq RAI \leq 0.75$) and extremely high adaptability ($0.76 \leq RAI \leq 1.00$).

4. Results

4.1. Demographic Sample Analysis

Among the 487 residents in this survey, males were the majority, accounting for 67.76% (Table 2), indicating that men dominate in the families in the survey area. There were more residents over 40 years old, of which 6.78% are over 65 years old. Except for the Han residents, there were more Tibetan residents, followed by the Yugur. Families' main source of income was grazing, supplemented by other income methods (such as planting crops, wage income obtained from ecological protection work in national parks, etc.). The annual income was mostly between 30,000 and 50,000 ¥, which is basically in line with the income characteristics of residents in pastoral areas. Residents mostly lived in the experimental zone and peripheral zone, although the grassland of the residents was still in the core zone and buffer zone, so there were still grazing activities in the core zone and buffer zone, which meets the needs of this survey.

Table 2. Demographic sample.

Survey Item	Type	Frequency (Sample = 487)	Percentage (%)
Gender	Male	330	67.76
	Female	157	32.24
Age	15–30	63	12.94
	31–40	149	30.60
	41–64	242	49.69
	Over 65	33	6.78
Nation	Han	242	49.69
	Tibetan	136	27.93
	Yugur	82	16.84
	Du	16	3.29
	Hui	9	1.85
	Mongolian	2	0.41
Annual household income (¥)	≤10,000	63	12.94
	10,000–30,000	181	37.17
	30,000–50,000	120	24.64
	50,000–70,000	77	15.81
	≥70,000	46	9.44
Source of income	Grazing	-	32.79
	Planting crops	-	9.70
	Self-employed income	-	5.82
	Wage income	-	31.77
	Government subsidies	-	9.46
	Other	-	10.47
Functional zone in protected areas	Core zone	70	14.37
	Buffer zone	109	22.38
	Experimental zone	191	39.22
	Peripheral zone	117	24.02

4.2. A General Analysis

4.2.1. Who/What Adapts?

"What adapts?" in this paper indicates the adaptability of local residents to policy, economy, ecology, society, culture and psychology. To categorize households, we classified the respondents on the basis of their income into nine types. They are H, H&F, H&W, F&H, F, F&W, W&H, W&F and W. Here H means herding, F means farming and W means having a job outside the QMNPP. If a respondent is categorized into type H, F or W, it means that he/she only has herding, farming or working as a livelihood, whereas types H&F, H&W, F&H, F&W, W&H and W&H mean that the income of the respondent depends on two sources. Taking H&F as an example, the respondent's livelihood source mainly comes from herding and a small part of farming, and the other types are alike.

Survey data (Table 3) presented that, among 487 respondents, type H&W (25.5%), W&H (18.1%) and W&F (15.6%) composed most of the respondents in the QMNPP, while type F was the lowest, meaning that very few people in the QMNPP took farming alone as their livelihoods. This result is consistent with the physical environment of the QMNPP, where the elevation is relatively high and is suitable for herding rather than farming.

Table 3. Number of livelihood type surveyed in the QMNPP.

Livelihood Type	H	H&F	H&W	F&H	F	F&W	W&H	W&F	W	Total
Number	23	18	149	3	1	9	97	84	103	487
Ratio (%)	7.6	8.2	25.5	1	0.2	2.7	18.1	15.6	21.1	100

4.2.2. How Does Adaption Occur?

(1) Adaptability analysis

The analysis of variance was used to analyze the RAI. Significant differences of RAI ($p < 0.05$) were detected, and the result is W&H > H&W > W > W&F > H > F&W > H&F > F&H (Figure 3: left).

	RAI(means ± deviation)
H	0.46 ± 0.17
H&F	0.46 ± 0.13
H&W	0.54 ± 0.18
F&H	0.35 ± 0.22
F&W	0.46 ± 0.20
W&H	0.56 ± 0.22
W&F	0.47 ± 0.18
W	0.48 ± 0.19
F	2.965
p	0.003**
* p<0.05 ** p<0.01	

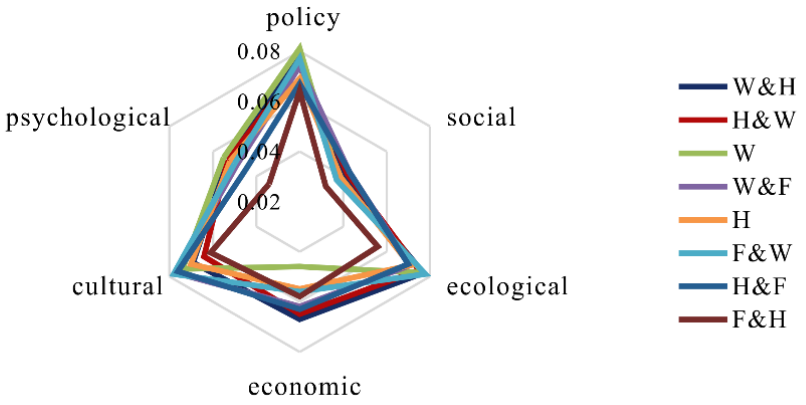

Figure 3. Result of analysis of variance and the adaptability of different livelihood types in different domains.

It can be concluded that local resident adapted policy change the most (Figure 3). However, different types of residents adapted it differently ($p = 0.002$ **, ** $p < 0.01$). Type W had the highest ability to adapt, followed by W&H and F&W, while type F&H was the lowest. Indeed, over the past twenty years, polices implemented, including "Returning the grain plots to forestry and grass", "Fodder–livestock balance system", "Eco-migration", etc., mostly aimed to limit herding or cultivating in the QMNPP. Therefore, people whose income depended on herding or farming would be affected the most, while type W people, as their income comes from outside work, have been little affected. However, it should be noted that, though these policies have negative impacts on local residents' income, they are always made up by compensation. The existing ecological compensation is mainly reflected in the following aspects: eco-migration, forest ecological benefits, water-saving projects, returning the grain plots to forestry and grass, biodiversity protection, nature reserve protection, etc. [45,46]. Therefore, it is not surprising that, compared with other domains, policy adaptability is the highest.

The p value of ecological adaptability was 0.069 ($p > 0.05$), indicating that nearly all respondents had same feelings regarding ecological change. This indicates high awareness of local residents to ecological protection. To understand this, there is a need to take a look at QMNPP's grassland degradation over the past decades. In the early 2000s, grassland degradation was a very serious issue for the area due to overgrazing, and it had seriously affected local residents' livelihood. On the one hand, policies were carried out to limit the number of livestock. On the other hand, livestock health was affected because of the degraded grassland. After years of restoration and along with increasing of income, local residents obtained a better understanding of the relationship between grassland and the number of livestock. Therefore, they were willing to take part in ecological protection.

Referring to economic adaptability, the p value was slightly higher than that of social adaptability and psychological adaptability. The economic adaptability of residents' livelihood types was significant at the 0.01 level ($F = 22.254$, $p = 0.000$ **), indicating that different types of residents had very different economical adaptability. The results are: type W&H had the highest adaptability (0.067), followed by H&W, and type W had the lowest (0.046). Generally, nomads in the QMNPP have the highest income. Therefore,

the residents whose income mainly comes from grazing and also have family members working outside showed the highest adaptability. However, for type W, most of them worked as forest rangers, grassland rangers, protection station managers, and in mass prevention and mass treatment, for which salaries are very low, and thus they showed very low economic adaptability.

With reference to cultural adaptability, great discrepancies ($F = 2.650$, $p = 0.008$) are noticeable. Types F&W and W&F had relatively higher p values. This is because people in these types are mainly Han people whose culture is much more adaptable than ethnic groups, including the Tibetan, the Yugur, etc. Because the Han culture is more resilient than ethnic groups, it usually shows a strong ability to withstand external disturbance. Compared with the Han people, the most obvious difference is the language. Ethnic groups have been influenced by their own languages since childhood, and their cultural values and behavior are deeply rooted. Moreover, their native language will make it difficult for them to contact the new cultural environments. In addition, the religious traditions and customs of some ethnic groups are more conservative and strict than those of the Han people, which also lead to some restrictions on adaptive behavior. Furthermore, due to the differences in ideology, economic level and educational resources, the education of ethnic groups is weaker than Han people, which leads to the relatively strong learning ability of the Han people. This was confirmed in the in-depth interviews.

Nevertheless, residents showed very low adaptability in the social ($p = 0.045$) and psychological domains ($p = 0.055$). This is consistent with our field survey. During the survey, many respondents complained of the poor infrastructure because there are restrictions on building new infrastructure. Moreover, people living inside the reserve mostly are old or little-educated, and they need social care more than others. They have been accustomed to everyday life in the reserve, and thus the adaptability to external culture or environmental change is low.

(2) Adaptability analysis in different regions

As different functional zones (i.e., core zone, buffer zone, experimental zone and peripheral zone) in protected areas of China are managed differently, the households were classified into four groups in accordance with their living locations. After 2017, all residents in the core zone have moved into the experimental zone and peripheral zone. In this paper, the residents in the core zone refer to those whose pasture is located in the core zone. It can be seen in Figure 4 that, though with a little difference, all zones' residents' adaptability levels show similar result. However, their adaptability to the six domains differs (Figure 5).

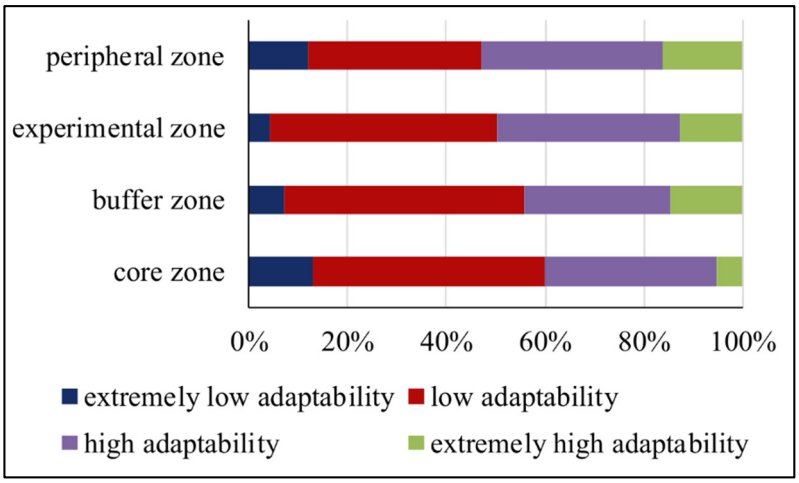

Figure 4. Adaptability of residents in different functional zones.

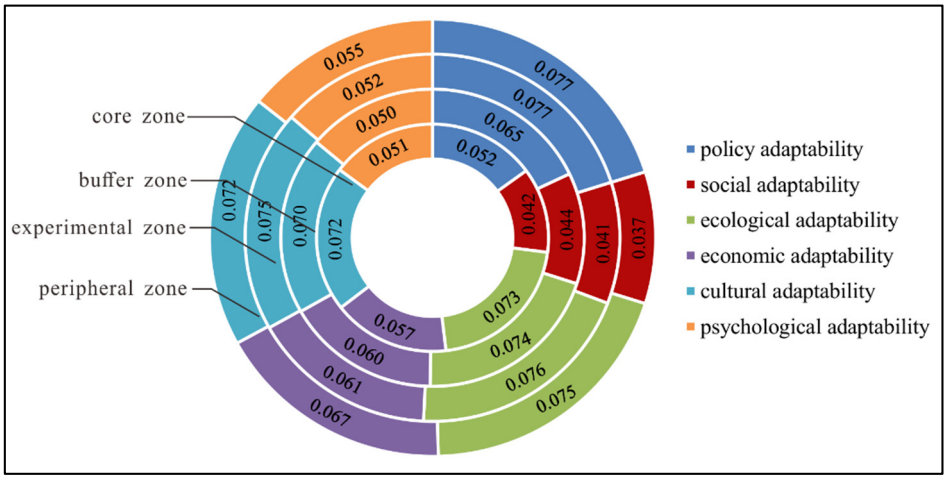

Figure 5. The adaptability of different regions in different dimensions.

As far as policy adaptability are concerned, the result presented that policy change affected the people living in the core zone the most, followed by the buffer zone, experimental zone and peripheral zone. This is easy to explain because the core zone and buffer zone of the QMNPP are located at relatively high elevations that are only fit for herding. People living in these areas are accustomed to herding and have no other job skills. Their ability to accept new things is low and they have difficulty changing their ways of livelihood. People from the experimental and peripheral zones, however, as their livelihood changed little under the new policy, showed high policy adaptability.

On the contrary, people's economic adaptability showed an opposite sequence, where peripheral zone > experimental zone > buffer zone > core zone. As a matter of fact, livelihood in the QMNPP is highly related to the elevation. People's livelihoods in the core zone and buffer zone highly depends on grazing animals, while people' livelihoods in the other two zones are much more diverse.

The *RAI* of residents of the other four domains, including social adaptability, ecological adaptability, cultural adaptability and psychological adaptability, presented little difference among the four functional zones. Only the *RAI* of residents in the periphery zone for psychological adaptability was slightly higher than that of other regions.

4.3. Impact Factors

To avoid collinearity among indicators, stepwise regression analysis was adopted to study the relationship between indicators and RAI. In the stepwise regression analysis, all indicators were considered independent and RAI-dependent. The regression equation model is as follows:

$$RAI = -1.531 + 0.502A1 + 0.566A2 + 0.223B1 + 0.180B3 + 0.175B4 + 0.465B5 + 0.341C1 + 0.532C2 + 0.107D1 + 0.296D2 + 0.249D3 + 0.337D4 + 0.293E1 + 0.535E3 + 0.281E5 + 0.546F1 + 0.473F2$$

The results ($R^2 = 0.849$, $F = 155.625$, $p = 0.000 < 0.05$) showed that the model was effective. It presented that the *RAI* in the QMNPP was affected by 17 factors (Table 4). To level them, these factors were divided into three grades: high influencing factors ($\beta \geq 0.200$), medium influencing factors ($0.100 < \beta < 0.200$) and low influencing factors ($\beta \leq 0.100$).

Table 4. Regression analysis results of influencing factors on residents' adaptability in the QMNPP.

Factors	Constant	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	VIF
		B	Standard Error	*β*			
		−1.531	**0.095**	**-**	**−16.153**	**0.000 ****	**-**
Policy knowledge	A1	0.502	0.090	0.139	5.563	0.000 **	1.935
Policy satisfaction	A2	0.566	0.098	0.154	5.796	0.000 **	2.213
Social network	B1	0.223	0.090	0.052	2.490	0.013 *	1.347
Household labor	B3	0.180	0.048	0.071	3.735	0.000 **	1.138
Education level	B4	0.175	0.057	0.057	3.061	0.002 **	1.090
Physical health	B5	0.465	0.043	0.204	10.825	0.000 **	1.105
Knowledge of SES	C1	0.341	0.096	0.099	3.557	0.000 **	2.410
Ecological awareness	C2	0.532	0.102	0.133	5.232	0.000 **	2.017
Satisfaction of income	D1	0.107	0.054	0.041	1.982	0.048 *	1.317
Livelihood diversity	D2	0.296	0.041	0.138	7.300	0.000 **	1.113
Household income	D3	0.249	0.060	0.079	4.118	0.000 **	1.133
Natural assets	D4	0.337	0.072	0.088	4.683	0.000 **	1.095
Ethnic costume	E1	0.293	0.068	0.110	4.311	0.000 **	2.029
Ethnic languages	E3	0.535	0.064	0.218	8.309	0.000 **	2.139
Traditional festival	E5	0.281	0.077	0.099	3.646	0.000 **	2.297
Acceptance of external culture	F1	0.546	0.072	0.189	7.585	0.000 **	1.932
Family resilience	F2	0.473	0.066	0.144	7.181	0.000 **	1.256

Dependent variable = *RAI*; D-W = 2.065; * $p < 0.05$ ** $p < 0.01$; $R^2 = 0.849$; $F(17,469) = 155.625$; $p = 0.000$.

It can be concluded that two factors (i.e., B5 and E3, namely physical health and ethnic languages, $\beta = 0.204$, $\beta = 0.218$, respectively) are high influencing factors (Table 4). From an individual's perspective, physical health reflects the vitality and sustainability of the social system. It determines people's development ability. People in poor health always show little adaptability to outside disturbance. In terms of ethnic language, people living in the reserve are mainly ethnic minorities. Most of them can only speak local languages, and thus there is an obstacle for them to adapt to the outside world.

A1, A2, C2, D2, E1, F1 and F2 are medium influencing factors. It is policy that determines living standards in the reserve. It further affects social, ecological, economic and psychological adaptability. Therefore, the higher the policy knowledge and satisfaction, the more stable the SES is. The indicator ecological awareness (C2, $\beta = 0.133$) reflects residents' willingness, attitude and behavior regarding ecological protection. Livelihood diversity (D2) directly affects household income, reflecting that the higher the livelihood diversity of residents, the better they can adapt to changing SES. The indicator acceptance of external culture (F1) is related to the adaptation of one's own ethnic culture and the diversity of livelihood. In general, the more ways of livelihood residents have, the more changes they are exposed to, and the higher their response to changes. Perception of household resilience (F2) can reflect residents' self-confidence in the face of environmental change, and directly affect their enthusiasm and initiative.

Other indicators are low influencing factors. Among these factors, social network (B1) is an important condition for the social system to be active. In the reserve, some residents live far from each other. Due to poor infrastructure, their social network is thus very poor. The structure and quality of family members are the basis of family adaptability. Household labor force (B3) and level of education (B4) directly affect the livelihood of residents, further affect the family income, and finally affect the development of the social system. Income satisfaction (D1) and annual household income (D3) affect residents' consumption elasticity and quality of life.

4.4. Adaptability Mechanism

Residents' behavior is not only affected by their own conditions, but also affected by the background environment of their region. However, the impacts of external environmental changes on residents are difficult to be measured quantitatively. The social-ecological system framework (SESF) proposed by Ostrom (2009) provides an ideal tool to analyze the adaptation mechanism [47]. SESF includes all of the resources involved in the interaction process of human society and ecosystem as well as the social, economic, political and ecological settings. There are four subsystems in the framework (Figure 6): Resource System (RS), Resource Units (RU), Governance System (GS) and Actors (A). The four subsystems interact and produce outcomes under the background of the social system and ecosystem, and emphasize actors' utilization behavior of resource units from the resource system. The interaction can effectively explain the adaptation mechanism of residents.

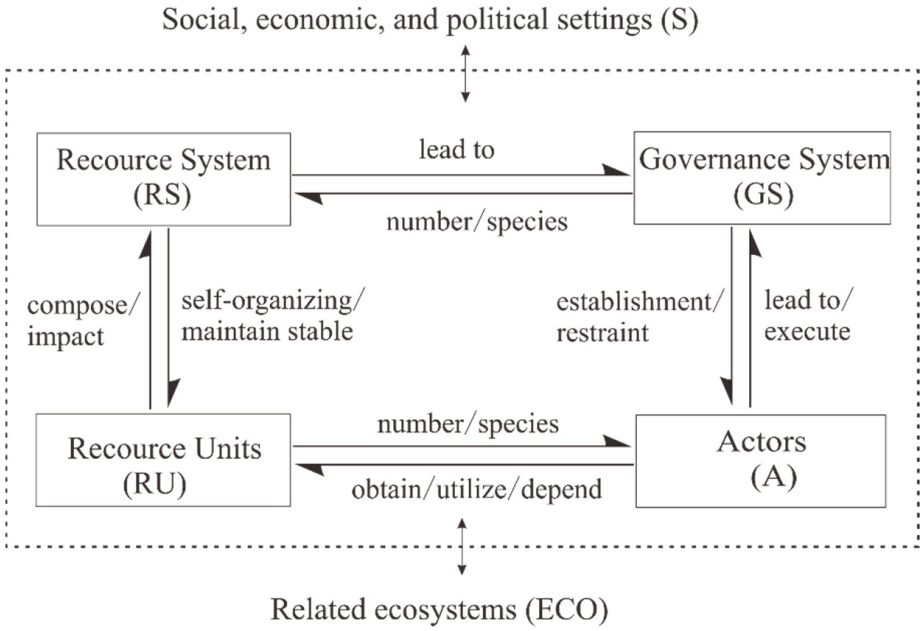

Figure 6. SES adaptability mechanism of residents (Ostrom, 2009, [47]).

The RUs in the national park are rich and diverse, including forest, grassland, wildlife, mineral resources, etc. The interaction and transformation of RUs can ensure the stability of the ecosystem through positive and negative feedback. The actors in this paper were local residents. In the early 1950s, logging was still permitted in the QMNPP. As a matter of fact, it once was treated as a major industry for local governments, which resulted in 50% loss of forest area. In the early 1980s, logging was forbidden. And from the year of 2000, a reforestation project was conducted under the Natural Forest Protection Project Policy. Then, forest area increased. In terms of grassland, here is a long history that nomads grazed in this region. As China's civil war ended in the end of the 1940s, the number of livestock increased along with a rapid human population increase, leading to severe grassland degradation. Upon this background, the GS played an important role by enacting policies to limit the number of livestock and prohibit grazing. Moreover, grassland was demarcated into plots for households rather than the previous situation in which people could graze anywhere as seasons changed.

For residents, most of these adaptive behaviors were passive and influenced by policy. When asked about the prohibition of grazing, one resident said, "We don't agree with the grazing prohibition completely. In the core zone, since grazing has been banned, grass has grown very thick, which is prone to fire in the winter. But being constrained by policy, we have no choice but to stop grazing." After grazing was forbidden, the ecological environment has improved, but the main source of income in the QMNPP was limited; "in

order to maintain the normal operation of life, we have to choose to work in other places, or dig up the *Cordyceps sinensis*, or other ways to support the family." The livelihood has changed from only herding or farming to combined occupations. This change in behavior was spontaneously adopted by residents. After implementing the grazing prohibition, the GS found that the local social and economic development was restricted. Therefore, the GS alleviated social problems by providing more employment opportunities, such as forest and grassland rangers, and encouraging the development of franchising, etc. Moreover, on the premise of not destroying the stability of the grassland resources system, residents were allowed to graze properly to maintain the sustainable development of the social system. In addition, residents also adjust the ecological health of grassland system through rotational grazing and rest grazing, so as to achieve a win–win situation of ecological benefits and economic benefits.

From the analysis above, It can be concluded that a resource system maintains the balance of the resource units through self-organization. Resource units' interaction will affect the stability of the resource system in turn. The governance system plays a role in regulating the residents' behavior. Residents obtain resource units in the resource system to meet their livelihood needs, and are dependent on the natural resources. Residents have both positive and negative behaviors. Positive behaviors, such as returning farmland to forests and grasslands, will increase the amount of grassland resources, while negative behaviors such as overgrazing will reduce the amount. The negative impact will lead to the establishment of rules and policies for a governance system (environmental protection policies, such as a fodder–livestock balance system, eco-migration, etc.). The behavior of residents will be restricted by these policies. Moreover, there is a continuous and complex interaction between social systems and ecological systems. It is thus clear that the adaptive behavior of residents is caused by legal policies and survival needs. The legal policies are the basis of residents' adaptive behavior, and the survival needs are internal motivation.

5. Conclusions and Implications

As China's policy on protected areas will undoubtedly get stricter in the future, people's perception and adaptation should be considered; this is similar to the conclusions of Jia et al. (2022) [48]. For years, the reserve was managed just like other remote areas that are not reserves in China, except that logging and hunting were forbidden. Policy change could bring much adaption issues for local residents. The findings of this article are consistent with the research conclusions drawn by Yin et al. (2020) that the policy of ecological restoration is the external thrust of farmers' adaptive behavior choice [36]. This study showed that the comprehensive evaluation of residents' adaptability index in the QMNPP is at a low level. Residents of different livelihood sources and different regions had different adaptability levels. The high adaptability groups are mainly formed by the combination of high policy adaptability, ecological adaptability, economic adaptability, cultural adaptability and stable ecosystems. These groups are mainly residents living in the experimental zone and peripheral zone. However, residents' social, economic and psychological adaptability were low.

To improve the adaptability of residents and enhance management effectiveness, it is possible to suggest improving education quality in the reserve as more and more young people are going out to search for higher salaries and population is decreasing in the reserve. For the long run, people with higher education would not like to stay in the reserve any more, which will further decrease the population in it. Then, land rights should be gradually changed as people move out. Land located at the core zone and buffer zone should be purchased by the government from local residents who already work outside the reserve. However, the government should pay more attention to these who have lived for many generations in the core zone and buffer zone. Most of these people are elders and ethnic groups, who showed very low adaptability in nearly all domains. While most of them have been moved out, this paper suggest that infrastructures could be built at their new home locations. Moreover, pasture land could be set around their new homes to

maintain their life style, though income from the pasture land would be very low compared to their previous pasture land.

The analysis framework of residents' adaptability in the QMNPP constructed in this study was intended to provide a tool for adaptability analysis in protected areas. This framework emphasizes the selection of adaptability indicators, which is more comprehensive than the existing indicator system, mainly taking into account various indicators of SESs, including policy, cultural, economic, ecological, social and psychological domains. In addition, this framework focuses more on the whole process of adaptability, deepens the study of the adaptability of residents from the perspective of system integration, and also provides a theoretical analysis framework for the research of residents' adaptability to global environmental change. Moreover, residents are the main actors of national parks or natural reserves. Adaptability is an important basis for the sustainable development of protected areas, and thus the results of this study can be used for reference for the community management of other protected areas. The index system needs to be verified and improved from the scientific and practical points of view. Additionally, only eight experts were included; however, we chose experts in different fields to score, which can reflect some problems to a certain extent. In future studies, we will increase the number of experts to make sure the data become more convincing. This study reflects the adaptability of residents in the QMNPP, but it is only one subsystem of the SESF (only an actor subsystem). Limited by data collection and processing methods, the current adaptability mechanism focuses on qualitative discussion. In further research, we will construct the SESF of Qilian Mountain, conduct further data collection, and use a combination of qualitative and quantitative methods to analyze the interaction between the four core subsystems of Qilian Mountain.

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