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Facing Climate Change: What Drives Internal Migration Decisions in the Karst Rocky Regions of Southwest China

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Abstract: Global climate change and its influence on human migration have caused heated debates. There is no consensus about the role of environmental change in shaping migration decisions. To amass more evidence and develop a deeper understanding of the relations between the environment and migration, this paper seeks to evaluate the importance of various drivers (economic, social, political, demographic, and environmental drivers) and determine the internal mechanism in the decision process. The Likert scale was used as the tool for measuring each respondent's perception of the drivers, and the within-group interrater agreement index was used to express the survey data and to select the actual driving forces. As a result, economic, social, and political factors were strong forces that promoted migration directly, while demographic and environmental factors were moderate or weak forces that promoted migration indirectly. The migrants' core consideration was to effectively reduce family risks and sustain their livelihoods by moving to a destination to improve their household income, keep their original social networks, and obtain housing allowances from the local government. Land degradation and meteorological disasters were rooted in the vulnerability and risks of a family, and these factors indirectly influenced the people's decisions by affecting the socioeconomic drivers. We concluded that isolating the environmental drivers from other drivers underlying migration decisions is difficult. Additionally, the internal mechanism indicated that both environmental and non-environmental factors all have an impact on choice in different ways. Future policies should be aimed at increasing sustainable livelihoods and the social resilience of migrant families at a personal level, balancing the development levels of the original locations and destinations, and strengthening international cooperation to reduce the negative effects of climate change at the regional level.

Keywords: climate change; migration decisions; drivers; family risks; livelihoods

1. Introduction

It seems that people in extremely impoverished regions face a dark future when confronting the environmental change resulting from greenhouse gas emissions. Myers claims that there could eventually be hundreds of thousands of "environmental refugees" at risk of displacement owing to direct or indirect environmental problems [1]. Hence, there has recently been an increasing interest in the relationship between human migration and environmental variation (including the environmental risk, stress, and uncertainty caused by climate change). Regardless of the debates on controversial terminology, such as "environmental refugees" and the diverse predictions concerning the amount of future migration flow, the role of the environment and environmental change in driving human migration activities still requires robust research.

A decision to migrate usually means that a family or an individual cannot obtain sufficient utility or support from the original location and seeks to move to a substitute location to better satisfy their needs and desires [2,3]. However, the decision to migrate is determined by many different drivers [4]. Richard Black developed a framework that identified five clusters of drivers (including economic, political, social, demographic, and environmental drivers) in the context of climate variability and environmental deterioration [5]. Therefore, the environment is regarded as a new primary factor driving the displacement of people. The mechanism is that climate change causes a series of environmental disruptions, including storms, floods, droughts, land degradation, sea level rise, and so on, resulting in the inability of people with high vulnerability to survive. These people have no choice but to leave their homes [6]. However, precisely distinguishing environmental factors from all driving forces is likely to be difficult because the motivations of migrants coupled with family characteristics, which are influenced by vulnerability and adaptation strategies, are generally diverse and complex [7]. It is generally believed that migration is a conventional choice used by households to cope with slow or sudden environmental variation to temporarily or permanently establish new livelihoods [8]. There is a perception that environment-induced relocation is an invalid mitigation of family in origin and a passive livelihood reconstruction in destination [9,10]. However, some researchers argue that this assumption was derived from merely common sense and that the relations postulated between environmental change and human mobility have not been explicitly demonstrated [11]. In reality, migration is treated as a result of far more complex behavioural decisions. A persistent perspective is that focusing on environmental factors in the process of making migration decisions may overlook the influence and underestimate the adaptive capacities of local residents [12]. Black notes that although one may be forced to migrate in response to climate change, the migration may not necessarily take place. A variety of living strategies are affected by personal and family characteristics, and barriers or obstacles may influence outcomes [5]. Rather, the effect of environmental drivers associated with other drivers can hardly be demonstrated in detail [13]. This inadequacy is partly because of the high levels of uncertainty about the nexus between climate change and human society, and partly because it is not clear whether migration means a failure to adapt or if it is an initiative diversification strategy [14]. Tacoli holds the idea that changing the radical understanding of the role of mobility is urgent, especially after drawing on some specific examinations and classifications of displaced persons. Migration is a useful strategy for reducing vulnerability and increasing economic and social flexibility rather than simply an escape from environmental marginalization in one's home [15]. Thus, Brown argues that the scarcity of reliable evidence regarding the relationship between environmental change and migration has rightly suggested this heated topic to be 'complex and unpredictable' [16]. Additionally, there is still a lack of rigorous research and empirical evidence regarding the details of the main drivers that promote migration. There is a growing consensus that multiple and interdependent causes (i.e., economic, social, political, demographic, and environmental factors), work together to impact migration flows in the context of environmental degradation [17–19].

The Intergovernmental Panel on Climate Change (IPCC) report predicted that decreases in rainfall could pose a grave threat to human society over time, and as many as a billion people in Asia could face freshwater shortages by 2050 [20]. A reduction in rainfall is one of the culprits of drought and desertification in arid and semi-arid areas across Africa, Asia, Central America, and Southern Europe [21]. Thus, a desertification trend could be a direct and predominant contributing factor to migration owing to variations in rainfall. Consequently, declines in crop productivity could induce families to migrate if their livelihoods cannot be sustained. Laczko deemed it a common response of people who live in areas at the risk of desertification to seek new opportunities elsewhere when agricultural and animal production fail to sustain local life [22]. Jacobson stated that land degradation has spoiled millions of hectares of cultivated soil and resulted in hundreds of thousands of poverty-stricken farmers sending themselves into exile in sub-Saharan regions [23]. Nonetheless, the existing evidence indicating that drought and land desertification cause migration and human mobility in any straightforward way remains insufficient. Many researchers have agreed with the opinion

that the linkage between drought and emigration is complex, and the latter is generally believed to be the last resort when in situ coping strategies have been exhausted. A case study investigated 45 sub-Saharan African (SSA) countries that were identified as having severe desertification and soil erosion conditions. The study demonstrated that the nexus was not simple and immediate because the motivations of contemporary emigrants were dominated by political and economic drivers, and the contributions of demographic and environmental pressures were less important and had an indirect impact on the migration decision [24]. For thousands of years, a tradition of the Sahel people has been to depart for a short period of time in the dry season, which is called 'circulation'. Nomadic pastoralism is usually called 'eating the dry season', which involves a range of adaptive strategies to relieve water stress and to diversify family livelihoods [25]. The remittances from these temporary labour migrants had been an important income resource for families, and sustained the lives of the family members remaining in the original locations. However, temporary human mobility is not equal to permanent relocation. Temporary migrations are an important way for families to reduce agricultural pressures and diversify their livelihood opportunities during dry periods [26]. Hence, desertification-induced migration is somewhat limited because environmental decline does not represent the main reason for people's flight, and desertification may be an overemphasized environmental factor that makes a small contribution to this myth [27]. There have been some quantitative analyses on the role of desertification on large migrations that evaluates the importance of environmental factors out of all the driving forces. To date, no consensus exists, and the conclusions of some reviews differ greatly and sometimes even contradict each other. For example, Gray found that outmigration doubled under severe drought in the rural highlands of Ethiopia, demonstrating that drought truly influenced population mobility [28]. In contrast, Naudé argued that political and economic factors were the predominant drivers in sub-Saharan Africa rather than environmental factors [24]. In summary, the conclusions of past studies, both qualitative and quantitative, concerning desertification-induced migration are still fragmented, and robust evidence on this issue is lacking.

By 2015, more than 55.75 million rural residents in China were living in complete poverty according to official government standards, and their annual income was less than 2300 yuan (at a constant price in 2010). The vast majority of these people lived in alpine regions, limestone mountain areas, the Loess Plateau, and other territories that could hardly sustain the livelihoods of local dwellers. These regions are characterized by harsh ecological conditions, fragile infrastructure, a low availability of public services and severe environmental degradation. Hence, the Chinese Central Government implemented a round of poverty alleviation and development programmes called "Targeted Poverty Alleviation Programmes" in the contiguous poor areas to "take targeted measures to help people lift themselves out of poverty" [29]. One of the measures in these poverty alleviation programmes was to relocate people living in ecologically fragile and climate-sensitive areas with insufficient natural resources. Guizhou Province, which is famous for its karst landforms, suffers from rocky desertification and is a typical representative of this type of area in China. The programme was intended to take five years and help a total of 1.34 million people in the poverty-stricken mountainous areas of Guizhou resettle to other regions with relatively good living conditions to re-establish sustainable livelihoods. The decision to move or stay in the original location was completely voluntary. Therefore, developing an understanding of the procedure of decision-making to migrate could help us to explore the drivers of individuals when facing climate change. Research on China's environmentally induced migration is a typical case study for the nexus between rocky desertification and population migration.

The aim of this study was to increase our general understanding of what factors drive migration in typical desertification regions of China under the background of frequent natural disasters, variations in rainfall, land degradation, and vegetation deterioration. More specifically, (1) in-depth analysis of the individuals' perception and evaluation of the importance of all factors during the procedure of making a decision to relocate was performed, and (2) the relations between each driving force and the internal mechanism of migration decisions were examined.

2. Materials and Methods

2.1. Study Area

The field study was conducted in Zhijin County in the central western area of Guizhou Province, Southwest China, as shown in Figure 1. Guizhou Province is characterized by typical karst landforms and is the only province in China without plain areas. The total area of karst outcrop covers 71% of the total area of the province, and the area of rocky desertification covers 3.59 million square kilometres [30]. Because of Guizhou's special landforms, with mostly hilly mountainous regions and limited cultivated lands available, the province cannot support modern agricultural production. The local agricultural economy is underdeveloped because of natural geographical conditions, infrastructure, and other factors along with natural disasters and frequent climatic variation. To some extent, the relation between humans and the ecological environment is very tense in that the economic activity of humans is subject to the environment. This situation also leads to severe deterioration of the environment. Grains and rhizomes, which are heavily dependent on natural conditions and usually very low yielding, are the main traditional crops. This situation has severely restricted the development of the local agricultural economy and has caused local labourers to fall into the trap of gripping poverty. The vast majority of the poverty-stricken people in Guizhou live in ecologically fragile and deteriorating environmental areas.

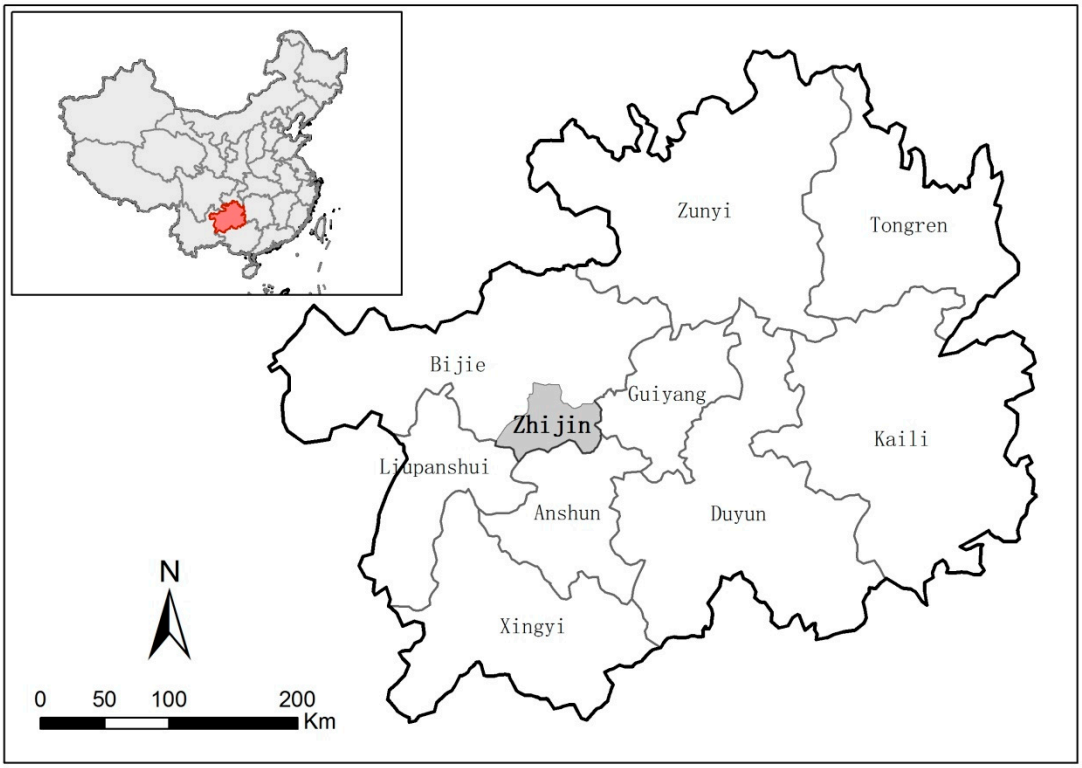

Figure 1. Location of Zhijin County. Source: National Catalogue Service for Geographic Information (China).

In the medium-long term, environmental change is likely to affect Zhijin County in two main ways: land degradation caused by karst rocky desertification and an increasing number of climate disasters. Moreover, the latter greatly exacerbates the former [31]. This type of land degradation refers to the process of severe soil erosion, the massive exposure of basement rocks, and serious vegetation deterioration that ultimately results in the appearance of landscapes such as deserts; in addition, the productivity of soil drastically decreases [32]. However, crop harvest loss is not the only outcome of desertification; desertification also destroys the local ecology and threatens human survival [33–35]. Because of ecosystem fragility, population pressures, and an irrational land-use model, Zhijin County is

highly sensitive to climate change [36]. There are two main types of climate disasters in Zhijin County. First, the alternation and frequent occurrence of droughts and floods have had a very negative impact on the growth of crops in the spring and summer. This situation further aggravates local water loss and soil erosion. Second, Zhijin County suffers heavy hail disasters annually, which mainly occur in April and May. Mild hail storms cause plant branches to fall off and decrease agricultural production, and serious storms impact the ability to harvest grain and threaten people's lives and property [37]. In summary, Zhijin County offers an ideal setting to explore the nexus between environmental change and human activities in the context of global warming.

2.2. Data Collection

In Zhijin County, the villages involved in the programme were investigated. Face-to-face interviews were conducted and structured questionnaires were given to a variety of respondents to collect data. We selected our respondents among the people who chose to resettle in 2017. A total of 213 households in 12 villages were interviewed door-to-door with the help of local village heads from 5–25 November, 2017. The natural resources and economic development level of villages in Zhijin County were greatly influenced by topography and geomorphology. In general, villages closer to the river valley have more arable lands and a more developed agricultural production level. Villages closer to the mountain have less arable lands and higher vulnerability. We chose 12 of the poorest villages in Zhijin County. All of them were located deep in mountain areas at high altitudes where there is no drinkable tap water, and communication and electricity are often blocked. From the perspective of population distribution, these 12 villages had not only Han-dominated villages but also Miao, Gelao, and other minority-dominated villages. In the event that the respondents gave 'protest' answers and protected their personal information, it was clearly explained to every respondent that the collected data would only be used for academic research, and individual privacy would not be disclosed after the survey. A total of 213 questionnaires were collected, and an effectiveness test was conducted. Among the surveys, 201 were valid, and the effective rate was 94.4%. From the sample of 201 farm households (see Table 1), men accounted for 59.2%, which was more than the percentage of women. The subjects were mainly middle-aged, accounting for 49.3% of the sample. The majority of the respondents had a low level of education: 83.6% had a level below primary school, and 1.5% had attended junior high school or above. The average land management area of rural households was 3.23 mu, of which the per capita dry land area was 2.09 mu, and the per capita paddy field area was 1.14 mu. The number of farm households with an operating area of 2.5–5 mu was the highest, accounting for 37.7%. Ethnic minorities accounted for more than half of all the migrants: the Han nationality accounted for 45.3%, the Miao nationality accounted for 30.8%, the Gelao nationality accounted for 20.4%, and the remaining ethnic minorities accounted for 3.5%. Each household was officially recognized as living below the national poverty standard, which means that these families cannot afford the cost of living without some financial assistance from the government. At their original locations, the people's livelihoods were based on traditional agricultural cultivation or concurrent farming and labouring. The local unique hilly landscape has made it very difficult to promote mechanized farming, and the agricultural yields have been unstable.

2.3. Methods

2.3.1. Research Framework

We developed a conceptual framework to make the basic theories and logics of this study clear, as set forth below in Figure 2:

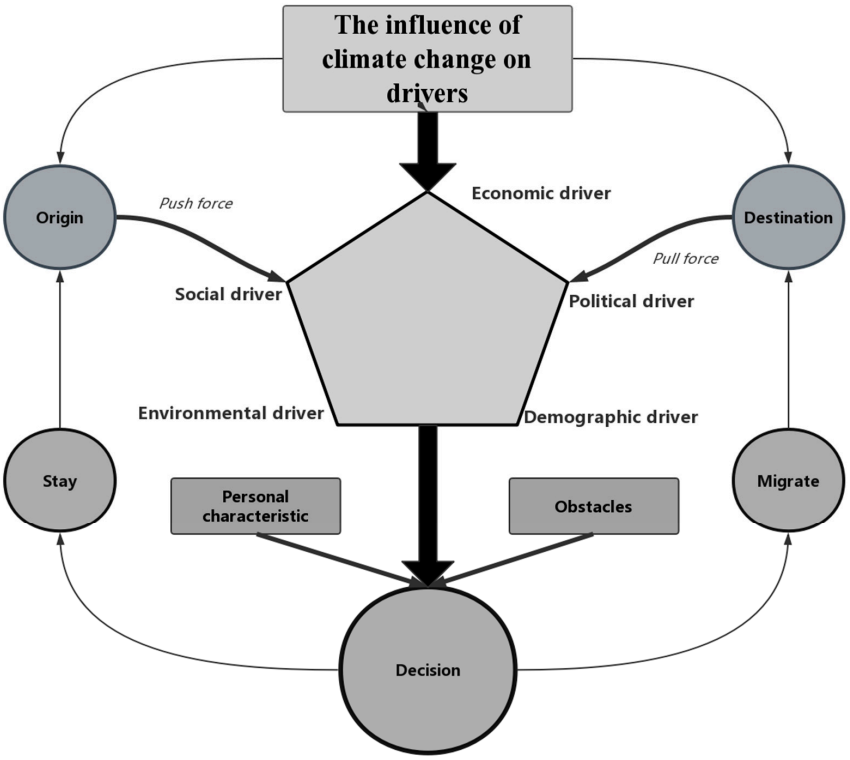

Figure 2. Research framework. Source: framework designed by the authors.

Table 1. Basic information on the respondents.

Factor	Index	Amount	Percentage
Sex	Male	119	59.2%
	Female	82	40.8%
Age	Under 18	5	2.5%
	19–40	61	30.3%
	40–64	99	49.3%
	Over 65	36	17.9%
Educational background	Illiterate	50	24.9%
	Primary school education	118	58.7%
	Middle school education	30	14.9%
	Junior high school education or above	3	1.5%
Nationality	Han	91	45.3%
	Miao	62	30.8%
	Gelao	41	20.4%
	Other	7	3.5%
Family-owned farmland (dry land)/mu	Below 0.5	14	7.0%
	0.5–1	27	13.4%
	1–2	52	25.9%
	2–5	76	37.8%
	Above 5	32	15.9%
Family-owned farmland (paddy fields)/mu	Below 0.5	18	9.0%
	0.5–1	69	34.3%
	1–2	83	41.3%
	2–5	31	15.4%
	Greater than 5	0	0%
Source of family livelihoods	Crop farming	201	100%
	Breeding industry	77	38.3%
	Employed in the labour force	59	29.4%
	Running a business	19	9.5%
	Other	11	5.5%

Source: date collected during the field investigation.

2.3.2. Investigating and Selecting the Factors for Analysing the Drivers of Migration

Scales are one of the main tools for conducting psychological and behavioural research. Since Rensis Likert proposed the Likert scale approach in 1932, the scale has become the most widely used response scale in surveys and studies, especially in educational evaluations, market surveys, and environmental assessments [38]. This type of scale consists of a set of questions or statements related to a topic to indicate the respondents' attitudes, opinions, evaluations, or intentions regarding a certain subject. The general methods for using the Likert scale are as follows: (1) The respondents are given a set of statements related to an individual's attitude towards a specific issue, and these statements are classified as positive or negative. (2) After listening to the statements, all respondents are asked to choose among attitude options, which are classified into 5 levels, strongly agree, agree, undecided, disagree and strongly disagree, that best matched their actual thoughts on the structured questionnaire. (3) All options on the questionnaire are marked from 1 to 5 points, with 1 being 'strongly disagree' and 5 being 'strongly agree', to digitize the scale and quantify the options. Summing the scores of every question on the scale provides the total attitude score, which reflects the respondents' overall attitude towards the topic, with stronger agreement with the statements. Our scale was designed as follows in Table 2:

Table 2. Questionnaire.

Main Category	Aggregated Drivers	Description
Economic	Household income	Compared to staying at the original location, it can be expected that the household income will improve significantly at the destination.
	Job opportunities	Compared to the original location, the destination could offer more stable job opportunities.
	Family risks	At the original location, my family faces many kinds of risks that cause my family's livelihood to be insecure.
	Lack of subsistence	A lack of sufficient means of subsistence in the original location makes my family struggle in poverty.
	Trading market and financial services	Being far away from trading markets and financial services restricted my family's business activities.
Political	Occupation for public resources	The illegal occupation of public barren mountains and the use of forestry resources among community residents constitute a driving force to move.
	Rural land circulation policy	The policy allowed migrants to retain rural land ownership in the original location and circulate the land use rights to the local government, agricultural corporations or other farmers. This policy protects my land rights, and I can receive a certain sum of money every year.
	Housing allowance policy	The government provides a sufficient housing allowance for migrants to find shelter at the destination.
	Long-term development policy	I can be included in the urban social security system and urban social welfare programme after relocation.
Social	Remain with others	The decision to migrate was not only shaped by my personal choice, but also greatly influenced by a unique combination of circumstances, especially the choices of my relatives and friends.
	Social contact	I would have more opportunities to broaden my social networks and economic connections at the destination.
	Education or professional skills training	Adults would obtain relatively stronger professional skills training, or children would have better educational opportunities at the destination.
	Social status	I could obtain a legal permanent urban residence certificate and enjoy its convenience at the destination.

Table 2. *Cont.*

Main Category	Aggregated Drivers	Description
Demographic	Population pressure	Even though the original location is less densely populated than the destination, I feel relatively more life stress and competition.
	Family characteristics	Owing to the ages of my family members, my education background, vocational skills, health status, and marital status, my family prefers to change living locations.
	Health issue	At the destination, I could have better medical services and healthcare security.
Environmental	Meteorological disasters	Frequent hail disasters, irregular droughts, and floods made my family's crop yield unstable.
	Land degradation	Guizhou's unique karst rocky landscape leads to the overexploitation of natural resources and causes great human–earth relationship stress in my original community.

Source: questionnaire designed by the authors.

We tested the reliability and validity of the questionnaire. The results showed that the Cronbach's Alpha was 0.934 (>0.8), which means it was good value for the internal consequence of the scale [39].

The Kaiser–Meyer–Olkin (KMO) test was 0.832 (>0.8), and the Bartlett test of sphericity showed that both acceptances for the conduct of factor analysis were satisfied as shown in Table 3.

Table 3. Kaiser–Meyer–Olkin (KMO) and Bartlett's test.

Kaiser–Meyer–Olkin measure of sampling adequacy	0.831
Approx. Chi-square	882.054
df	196
Sig.	0.000

Source: the date was calculated by the authors.

To analyse these scores, we introduced the within-group interrater agreement (IRA or r_{wg}) suggested by James to judge the scores for a group of people [40]. The IRA as a measure for Likert scales are widely used to gather systematic observations of the consequences [41]. High agreement means that a group strongly identifies with an idea, and a low agreement indicates a low confidence in an idea. Moreover, the IRA index allows researchers to conduct further multilevel analyses of all individuals at the group level [42–44]. However, Schmidt and Hunter critiqued that the index contradicted the classical model of reliability [45]. Kozlowski and Hattrup argued that it was necessary to clearly distinguish the conceptual foundation of interrater agreement from interrater reliability. The IRA is a suitable index for explaining within-group interrater agreements but is unable to test reliability or consistency [46]. James considered Kozlowski's opinion and proposed a slightly more precise and faithful argument, stating that some basic assumptions and caveats should be satisfied: (1) The index should not be used to evaluate estimators of reliability. (2) The inherent tendencies of different people may impute a response bias, which is called the "interpretation effect", and having a common discrete scale for all respondents is preferable [47].

In this paper, we used a five-point Likert scale to justify the aggregation of every individual's responses: 1 means strongly disagree, and 5 means strongly agree. We referred to the expected variance as σ_E^2, which had a discrete uniform distribution. The calculation formula was as follows:

$$\sigma_E^2 = (A^2 - 1)/12, \quad (1)$$

where A refers to the total number of response categories. Based on the σ_E^2 value, we introduced the following equation:

$$r_{wg} = \frac{\sigma_E^2 - S_x^2}{\sigma_E^2} = 1 - (\frac{S_x^2}{\sigma_E^2}), \quad (2)$$

where S_x^2 is the observed variance of a rating given variable X. The IRA value of variable X ranges from 0 to 1; values closer to 0 indicate a relatively lower degree of agreement with a given question, and values closer to 1 indicate a relatively higher degree of agreement. George noted, and then LeBreton expanded, that the cut-off criterion for r_{wg} of the fit indices was 0.7, and if the value exceeded 0.7, the agreement was considered acceptable [48,49]. The mean value of these factors shows that when the score is closer to 5, the driving force is relatively stronger and direct, and when the score is closer to 0, the driving force is relatively weaker and indirect. In this paper, we combined three indices, (i.e., the mean value $\overline{x}$, the observed variance S_x, and r_{wg}), to evaluate the five different drivers pulling or pushing people's resettlement decisions. Relatively higher mean values, lower observed variances, and r_{wg} values above 0.7 together reflected which factor was the stronger motivator of migration.

3. Results

Different respondents expressed different preferences about these drivers owing to their personal characteristics. The results showed that 12 factors in the IRA exceeded 0.7, which means that the migrant groups developed a consensus about them. A strong driver is determined at a mean value between 3.5 and 5, a moderate driver is determined at a mean value between 2.5 and 3.5, and a weak driver is determined at amean value between 1 and 2.5. Then, we cloud selected the household income, job opportunities, family risks, lack of subsistence, housing allowance policy, and education or professional skills training as strong drivers; long-term livelihood development support, remaining with others, and family characteristics were moderate drivers; and population pressure, meteorological disasters, and land degradation were weak drivers.

3.1. Economic Drivers

As shown in Table 4, the expected improved salary levels at the destination presented the highest mean value, which demonstrated that household income was the strongest driving force among all the migration factors. This is because the income gap between the urban and rural areas remained large and the native countrymen had a strong willingness to obtain employment in the city. More job opportunities constituted a pulling force at the destination, while the lack of sufficient means of subsistence constituted a pushing force in the original location; together, these two forces promoted migration. According to Maslow's hierarchy of needs, physiological needs remain people's priority [50]. A substantial proportion of the respondents take reducing risks and the resulting uncertain crop yields as a consideration when facing climate change. Hence, diversifying source income is a very important strategy for families to have a sustainable livelihood. Similar to Neumann's research findings, employment change has become a significant economic factor driving human migration in degraded land areas [51].

Table 4. Perception of economic drivers.

Number	Item	$\bar{x}$	S_x	r_{wg}
A1	Household income	4.94	0.24	0.97
A2	Job opportunities	4.71	0.59	0.83
A3	Family risks	4.62	0.56	0.84
A4	Lack of subsistence	4.62	0.61	0.81
A5	Trading market and financial services	1.67	0.79	0.69

Source: data collected and calculated by the authors.

3.2. Political Drivers

As shown in Table 5, the housing allowance policy and financial assistance by the government at the destination had the second highest mean values, indicating that political factors play an important role in shaping the decision to migrate. The reason was that without the houses and capital provided by the government, these impoverished people could not afford the cost of resettling. Long-term development support policies were moderate drivers, which included the permission to become an official urban citizen and subsequently gain access to social security measures and the social welfare system. China has a long history of urban–rural social and economic disparities that have motivated a large number of rural inhabitants to move to cities.

Table 5. Perception of political drivers.

Number	Item	$\bar{x}$	S_x	r_{wg}
B1	Occupation for public resources	1.20	0.80	0.68
B2	Rural land circulation policy	3.83	0.97	0.53
B3	Housing allowance policy	4.87	0.34	0.95
B4	Long-term development support	3.59	0.71	0.75

Source: data collected and calculated by the authors.

3.3. Social Drivers

As shown in Table 6, adults' professional skills training or children's educational opportunities promoted people's desires to resettle because these poverty-stricken people generally accepted that a low educational level and lack of professional skills were at the root of their difficult situation. Strong professional skills training and improved children's education would end the families' poverty. The relatives' and friends' choices had a significant impact on individuals' migration choices, because this relocated population is composed of a large number of minorities that formerly lived in typical patriarchal societies. In this type of society, people are bound by blood relations and have strong economic and social ties with each other. Hence, making a migration decision based on relatives' or friends' choices was a moderate driver.

Table 6. Perception of social drivers.

Number	Item	$\bar{x}$	S_x	r_{wg}
C1	Remain with others	3.08	0.34	0.94
C2	Social contact	1.66	1.12	0.37
C3	Education or professional skills training	4.78	0.45	0.90
C4	Social status	2.96	1.07	0.43

Source: data collected and calculated by the authors.

3.4. Demographic Drivers

As shown in Table 7, maximizing the entire family's utility and benefits was the most important consideration for every family member. Generally, the families that chose to relocate typically had school-age children who needed to be enrolled in school, and the family members who had relatively high academic qualifications and professional skills also showed more positive migration tendencies. The choices of female family members were often consistent with the choices of the male heads of households. This occurred because the main consideration of the wives was to take care of the other family members. Population pressure was a weak driver. The respondents generally believed that, although the local natural resources and the family's per capita cultivated land were insufficient, the relationships between neighbours were not strained. Owing to the fact that ethnic minorities constituted the majority of the local community's population, the interpersonal relationships of one

community are linked by genetic relationships, traditional customs and habits, and common religious beliefs. Hence, including the Han nationality, the respondents generally perceived that the relationships between people in the village were a mutual help rather than a population pressure. Moreover, moving into a new community means the breakdown of the original social relations, inducing social network marginalization at the individual level.

Table 7. Perception of demographic drivers.

Number	Item	$\bar{x}$	S_x	r_{wg}
D1	Population pressure	1.90	0.68	0.77
D2	Family characteristics	3.32	0.54	0.85
D3	Health issue	1.82	0.94	0.56

Source: data collected and calculated by the authors.

3.5. Environmental Drivers

As shown in Table 8, meteorological disasters were a weak driver. There are two main reasons for this result. First, Zhijin is located in an area where hailstorms and other meteorological disasters occur annually, and the local farmers are accustomed to this reality. Hence, for long periods of time, the farmers in Zhijin have developed a series of in situ strategies to cope with these risks and disasters. Moreover, improved accurate weather forecasting can help people prepare well in advance to avoid the losses caused by disasters. Although there is a gradual and frequent trend of droughts, floods, and other disasters every year, the scale is generally small. In response to such disasters, the local government has constructed some small rural water resource facilities, including mountain spring collection systems and small dams, in various affected villages to reduce negative impacts. Land degradation was also a weak driver. The respondents generally believed that the low crop output caused by soil impoverishment and soil erosion could scarcely satisfy their family's living requirements. Furthermore, as China's economic development level continues to increase, agricultural products have become less expensive than industrial products, and it has become almost impossible for farmers to earn enough money to accumulate family wealth through agriculture. Thus, part-time jobs or small-scale businesses have become necessary for families to diversify their sources of income.

Table 8. Perception of environmental drivers.

Number	Item	$\bar{x}$	S_x	r_{wg}
E1	Meteorological disasters	1.31	0.66	0.78
E2	Land degradation	1.44	0.72	0.74

Source: data collected and calculated by the authors.

4. Discussion

First, we investigated the drivers of migration and found that all types of factors had an influence on the migration decision to some extent. The decision to migrate is the result of the contribution of multi-criteria pull and push factors. It is impossible to isolate a single typeof factor, especially environmental factors from others [51]. The role of environmental variation is not a predominant factor among all drivers because it coincides with other structural changes [52]. The socioeconomic drivers are strong driving forces that facilitate migration decisions because the regions characterized as fragile ecosystems could not provide enough services for local residents, resulting in high degrees of poverty. This situation directly threatened people's local sustainable livelihoods. Environmental factors were weak driving forces in facilitating migration decisions because the actual influence of environmental change is highly dependent on economic, social, and political factors. In this context, the role of environmental drivers should not be overemphasized. Relocating to another location was considered a rational decision to avoid risks and maximize families' net benefits to sustain

themselves. Understanding the complex causes underlying migration can help populations address climate change in high vulnerability areas. The socio-economic drivers are more dependent on the different choices of families at the personal level, and the environmental factors are chronic and rooted in other drivers at the regional level. Therefore, to alter the negative effects of environmental degradation, long-term adaptation and mitigation strategies need to focus on underlying and indirect factors, which requires international and regional cooperation within a broader framework, such as balancing the development level of different regions, formulating blueprints to reduce global greenhouse gas emissions, and establishing a harmonious relationship between humans and ecology. Simultaneously, to take better care of environmental migrants, contemporary assistance needs to focus on the strong and direct factors. These factors enable the realization of the core development goal, which is to strengthen the ability of resilience and reduce the vulnerability of a family when facing the risks caused by environmental variation [53,54]. Both environmental and non-environmental drivers constitute a systematic force in shaping migration. Isolating and overemphasizing environmental factors from other factors neither strengthens our in-depth understanding of this scientific issue, nor brings more help to migrants on the practical level [13,52].

Second, we synthesised the main factors that drove migration in typical land degradation areas. To express the internal mechanism of making a migration decision, a picture was designed for visualization. As shown in Figure 3, meteorological disasters and land degradation were at the top level of the decision process, which means that the environmental factors had indirect effects on migration decisions and had a great influence on the other factors. Moreover, meteorological disasters and land degradation facilitated each other in the worst situations. To better care for the populations suffering from environmental degradation, long-term measures to adapt to climate change are crucial in reducing local negative environmental impacts. Environmental factors directly caused population pressures and a lack of sufficient substances to sustain family living. Together with family characteristics, these three factors constituted great livelihood risks, especially for highly vulnerable families. Hence, family risks were at the core position of the decision-making process. To effectively reduce family risks, a cluster of measures, including economic, social, and political factors, was taken into consideration. Long-term development support was an economic safeguard that could help families gradually escape poverty. Social networks could be a strong internal motivator to facilitate migration by providing social capital. Relatives and friends could provide some key support, including job information, material assistance, spiritual encouragement, and the provision of new social ties, when a family resides in a new location [55]. A housing allowance policy made considering migration possible. These needy families cannot afford the cost of migrating without some external financial support. Finding shelter constitutes the largest proportion of the cost of migrating. The core consideration of long-term development support was to effectively improve household income by diversifying income sources. The improvement of household income directly affected two drivers. Over short periods, more stable job opportunities were a conventional way for a family to obtain income; over long periods, migrants needed to improve their professional skills to obtain better paid jobs. Bettering children's education effectively contained a family's poverty because the children could provide support for their family when they are grown up [56].

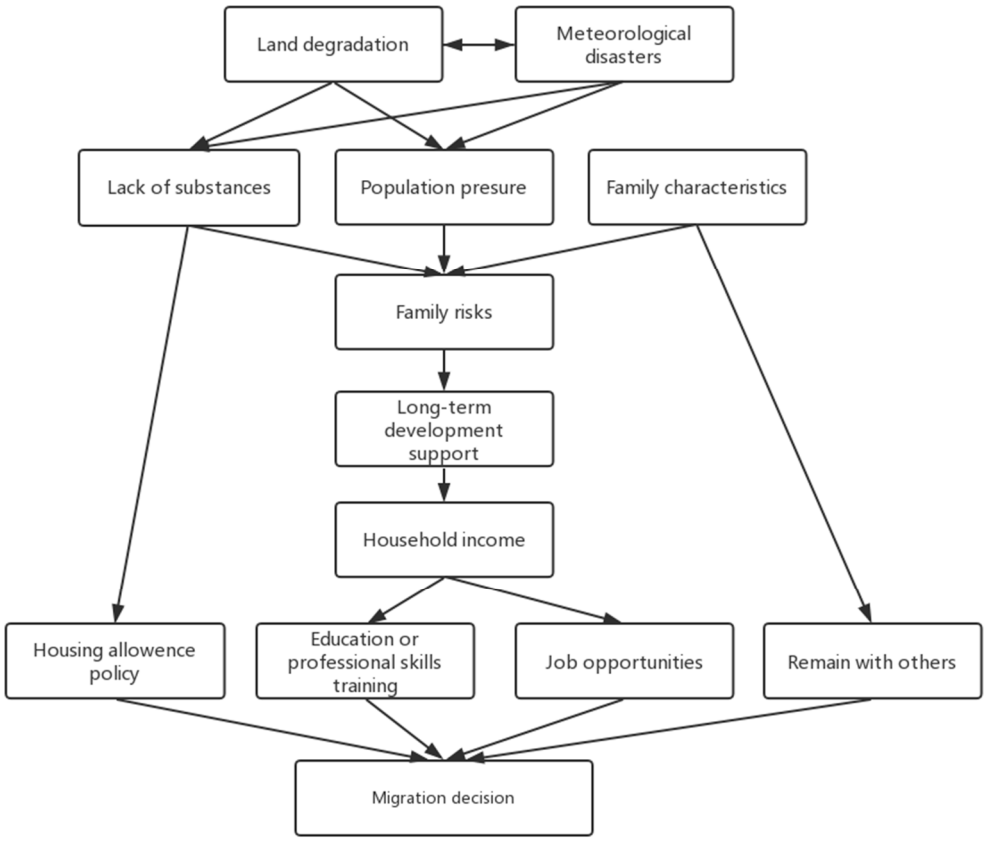

Figure 3. Internal mechanism of a migration decision. Source: the picture was designed by the authors.

5. Conclusions

This paper seeks to combine classical theories of human migration with the practices in Zhijin County to develop a deeper understanding of the internal mechanism of migration decisions in the context of global climate change in typical rocky desertification regions of Southwest China. We attempt to explain the complicated relations among the environment, migration and poverty alleviation in a 'micro' sense by investigating 213 respondents from 12 villages regarding their personal perceptions of their instinctual motivations and possible scruples when facing the choice of staying or leaving. Different drivers were weighed and classified as strong, moderate, and weak forces in promoting the relocation process, and we elevated the relations between different factors to explain the internal mechanism. The key research findings and their implications for policy and measure recommendations are discussed below.

First, after detailed performing a assessment of the migration decision process, we found that the economic, social, political, demographic, and environmental drivers all impacted on the choice to stay or leave. Moreover, different had a different effect on the process. Among all the driving forces, economic factors were the strongest driving forces and hada direct relationship with the sustainable livelihoods of migrants. Political drivers also had a great influence on the migration decision and ranked after economic drivers. This finding was related to the inability of poor families toafford the cost of moving and reconstructing their livelihoods without external assistance. Social and demographic factors wereweaker driving forces than economic or political factors. However, they werevital for the flow, direction, and type of migrations. The choice of migration was positively correlated with family characteristics and social networks. Environmental factors were the weakest driving forces. Although environmental factors themselves were less influential, they had a direct or indirect impact on other factors in migration decisions, especially through economic and demographic drivers. In sum, the decision to migrate was the result of the contribution of multi-criteria pull and push factors.

The second important contribution of the analysis was the identification of the underlying internal mechanism of migration decisions by clarifying the relations of different factors and positioning them in a hierarchical structure. The results indicated that environmental drivers are underlying factors that are deeply embedded in a family's socioeconomic status. A lack of substances and population pressure were caused by environmental degradation. Together with family characteristics, they constituted a great threat to sustainable livelihoods and increase the hardship of sustaininglocal populations. Hence, family risks are at the core of a family's decision-making process. Resettlement was treated as a conventional family strategy in order to both increase household income and reduce the risk of household expenditure failure by diversifying the source of revenue in a more developed economic region [57]. As a result, direct and strong drivers were deeply related to the migrants' livelihoods. The environmental factors wereweak and indirect drivers, and had their influence through socioeconomic drivers on peoples' choice.

Finally, future policies related to migration should be aimed at improving the lives of disadvantaged groups to facilitate the free movement of domestic populations instead of imposing restrictions on voluntary migration or exerting influence on the volume, direction, and types of human mobility. To achieve broader development goals, it is essential to radically change the obsolete perception of migration. Migration or human mobility could be an effective method of diversifying family income sources and to narrowing the widely unequal development levels of the economies between rural and urban areas [15]. Policymakers need to consider climate change-related rights for migrants, help migrants establish migration pathways, and treat both host and receiving areas together when facing global warming [58]. Reducing barriers to migration could not only greatly benefit the residents in highly vulnerable environmental areas and help them cope with climate change, but also balance the unequal development levels between the original and destination locations [59]. Based on the Zhijin County case, voluntary and managed resettlement could be an effective method ofreconstructing the living situations of climate-sensitive populations in their target destinations and restoring the ecosystems in the original locations. This planned resettlement could not be organized and implemented without some external assistance.

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