RESEARCH

Identifying factors influencing the spatial distribution of minority cultural heritage in Southwest China

Chang Li[1*], Yuyao Qian[1], Zhaokun Li[1] and Tong Tong[1]

Abstract

Minority Cultural Heritage (MCH) plays a crucial role in preserving human cultural and historical diversity. In Southwest China, there is a disparity between the abundance of ethnic minority cultural heritage resources and their inadequate protection and development. However, limited by interdisciplinary barriers, research into the distribution patterns of varied MCH in this area remains unexplored, making an initial step towards comprehensive preservation. The study investigates the relationship between MCH distribution and its association with factors of geography, climate, transportation, economics, and demographics, utilizing spatial geographic analysis, Geodetector methods, and social network analysis. The results indicate the following: (1) The distribution of 483 national-level MCH in Southwest China exhibits clustering, with a higher concentration in the southern regions. Honghe Prefecture, Dali Prefecture, and Qian-dongnan Prefecture serve as the core areas with high MCH density, accounting for 47.2% of the total concentration. (2) All three categories of MCH show cohesive distribution patterns. cultural heritage clusters in the northern to south-eastern regions of Yunnan Province, intangible cultural heritage clusters in the southeastern to southern regions of Guizhou Province, and agricultural cultural heritage clusters in the northern region of Yunnan Province. (3) The distribution of MCH among different ethnic minorities demonstrates polarization. The Yi and Tibetan ethnic groups have a higher quantity and diversity of MCH, while the Qiang, Lisu, and Jingpo ethnic groups have relatively fewer resources. (4) Single-factor analysis reveals that natural factors like the proportion of mountainous areas, river density, and annual average sunshine, as well as human factors like the proportion of minority population, urbanization rate, and road mileage, have the strongest explanatory power for the distribution of MCH. Furthermore, the interaction between these factors and others enhances the explanatory power for the distribution of MCH in Southwest China. This study provides scientific evidence for the assessment, protection, and sustainable development of MCH.

Keywords Minority cultural heritage, Spatial distribution, Influencing factors, Spatial geographic analysis, Geodetector, Southwest China

Introduction

Cultural heritage stands as a testament to the ingenuity and histories of societies, weaving together the tangible and intangible threads that make up the fabric of human civilization. Minority Cultural Heritage (MCH) stands out among diverse cultural heritages, encompassing an intricate mosaic of cultural relics, rituals, languages, and knowledge systems that define the ethnic identity of minority groups, frequently in stark contrast to the majority population. This study underscores the necessity

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of surveying the distribution of MCH, especially amid the continuous modernization and urbanization in Southwest China.

Under a broader categorization of heritages, MCH is divided into tangible and intangible types. Tangible cultural heritage includes enduring material expressions such as ethnic minority buildings, monuments, and artifacts. In contrast, intangible cultural heritage encompasses living expressions passed down through generations, such as ethnic minority folklore, music, and dance [1, 2]. Previous studies have highlighted the dynamic interaction between tangible and intangible heritage of ethnic minorities, demonstrating how tangible forms encapsulate intangible customs, as well as the important role intangible elements (e.g., folk traditions) play in activating cultural material heritage [3, 4]. Additionally, recognized as a distinct heritage by the Food and Agriculture Organization (FAO), agricultural heritage integrates both tangible and intangible domains, including materialized land-use systems (e.g. terraces) and intangible cultivation experiences and rituals (e.g. agricultural calendars) [5–7]. Despite the significant role of agricultural cultural heritage in demonstrating the symbiotic relationship between ethnic minorities and their environment, the comprehensive understanding of its connection to other forms remains to be investigated.

Studies on MCH within contemporary society have primarily concentrated on cognition, protection, and transmission. Numerous studies have examined the value and uniqueness of MCH from perspectives such as the digitized protection of heritage sites [8], traditional language experience in heritage tourism [4, 9, 10], the resilience of heritage communities [3, 11], the evaluation of heritage conservation policies [12, 13], and the institutional logic of heritage management [14–16]. Investigations have also addressed the impact of large-scale environmental changes and social transformations on MCH, focusing on both natural variables (e.g., sea-level rise, storms, and droughts) [2, 17–19] and social variables (e.g., industrial development and urban expansion) [20–22]. Despite advancements in our comprehension of MCH, there remains a research gap in the aggregate assessment of tangible, intangible, and agricultural cultural heritage, lacking a comprehensive interdisciplinary approach to evaluate them collectively.

Employing Geographic Information Systems (GIS) presents an innovative approach for assessing MCH. GIS is highly effective at mapping the spatial relationships and stories that shape regional cultural geographies, thereby improving the charting of cultural heritage, monitoring environmental changes, and devising strategies for resource conservation [23, 24]. GIS-based spatial analysis has been applied in various heritage categories across multiple regional studies, including studies on historical villages [25, 26], industrial heritage [27], archaeological sites [28, 29], intangible heritage [30, 31], and agricultural heritage [32]. Although spatial analysis has been widely adopted in regional studies that concentrate on specific types of cultural heritage, its application in minority areas remains limited. This oversight impedes a comprehensive understanding and the effective application of the patterns of distribution and evolution within cultural heritage.

The situation in Southwest China offers a salient example for addressing these challenges. The ethnic minority heritage mainly located in economically marginalized mountainous, hilly, and plateau areas, contends with a fragile balance within the "resource-environment-society" triad [33]. Recognizing this, the Chinese government has established a range of policies and economic assistance initiatives to strengthen the resilience of the socio-ecological environment, as well as to support the prosperity of ethnic minority cultural heritages [34, 35]. Nonetheless, a comprehensive understanding of how different MCH types are distributed regionally and their links to the natural and social environment remains elusive. This gap critically undermines the effectiveness of policies designed to identify conservation priorities, allocate resources efficiently, and tailor intervention measures accordingly.

Consequently, the objective of this study is to offer a novel perspective on cultural heritage study by identifying the general patterns and influencing factors related to the distribution of ethnic minority cultural heritage in Southwest China. It supports the development of more informed governmental and institutional decision-making processes, thereby facilitating the effective and sustainable protection of these heritages. This study aims to achieve the following three objectives through detailed depiction and comparative analysis: (1) to illustrate the geographic distribution of MCH across Southwest China, (2) to evaluate the spatial distribution differences among various ethnic groups and cultural heritage categories, and (3) to interpret how natural and human factors influence the locating of MCH.

Materials and methods
Study area
The study area is situated in the Southwest part of China, which is renowned for its diverse natural environments and rich ethnic minority cultures. It spans across 167,000 km^2. Mountains, basins, hills, and plateaus account for 4.85%, 1.55%, 4.96%, and 88.64% of the total area, respectively [36]. The climate displays a range of patterns, such as temperate, subtropical monsoon, and tropical monsoon, which are influenced by factors of

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altitude and latitude [36]. The region is home to Tibetan, Qiang, Yi, Miao, Dong, and Dai ethnic minority cultural areas, and has abundant cultural heritage resources from various historical periods [37]. The research centers on the ethnic minority settlement among provincial, municipal, and ethnic minorities in the Southwest ethnic areas (Fig. 1). The study encompasses 483 national-level sites of cultural significance for ethnic minorities, including the National Key Cultural Relics Protection Units (MHCSPL), Intangible Cultural Heritage of China (ICHC), and National Important Agricultural Heritage System (NIAHS), all of which have considerable historical, artistic, and scientific wort. Data on cultural heritage sources are derived from the latest lists published by the State Administration of Cultural Heritage, the Ministry of Culture and Tourism, and the Ministry of Agriculture and Rural Affairs [38–40].

Previous studies have identified multiple variables that affect the formation and development of cultural heritage, such as natural, social, and economic factors [30, 32]. This study examines the potential factors that may affect the outcome and divides them into two dimensions: natural factors (geography and climate) and human factors (population, economy, transportation, and culture).

The spatial distribution and patterns of ethnic minority cultural heritage in Southwest China are examined through the utilization of these factors. Data collection for all possible factors is measured based on the Minority Autonomous Prefecture (a particular division of the municipal administrative unit) where the MCH is located. For instance, the term 'river density' denotes the total length of rivers per square kilometer within each Minority Autonomous Prefecture. Statistical yearbooks from provincial and municipal administrative units, the China National Minority Statistics Yearbook, and the Chinese Academy of Sciences Resource and Environmental Science Data Center are among the data sources (Table 1). The study area does not include Tibet due to constraints in the data. The cutoff date for the statistical data in this study is October 31, 2023.

Research methodology
Kernel density estimation
Kernel density analysis is employed to assess the density and clustering of cultural heritage elements in geographic space. It calculates the density of MCH in Southwest China and identifies cluster regions. The formula is as follows:
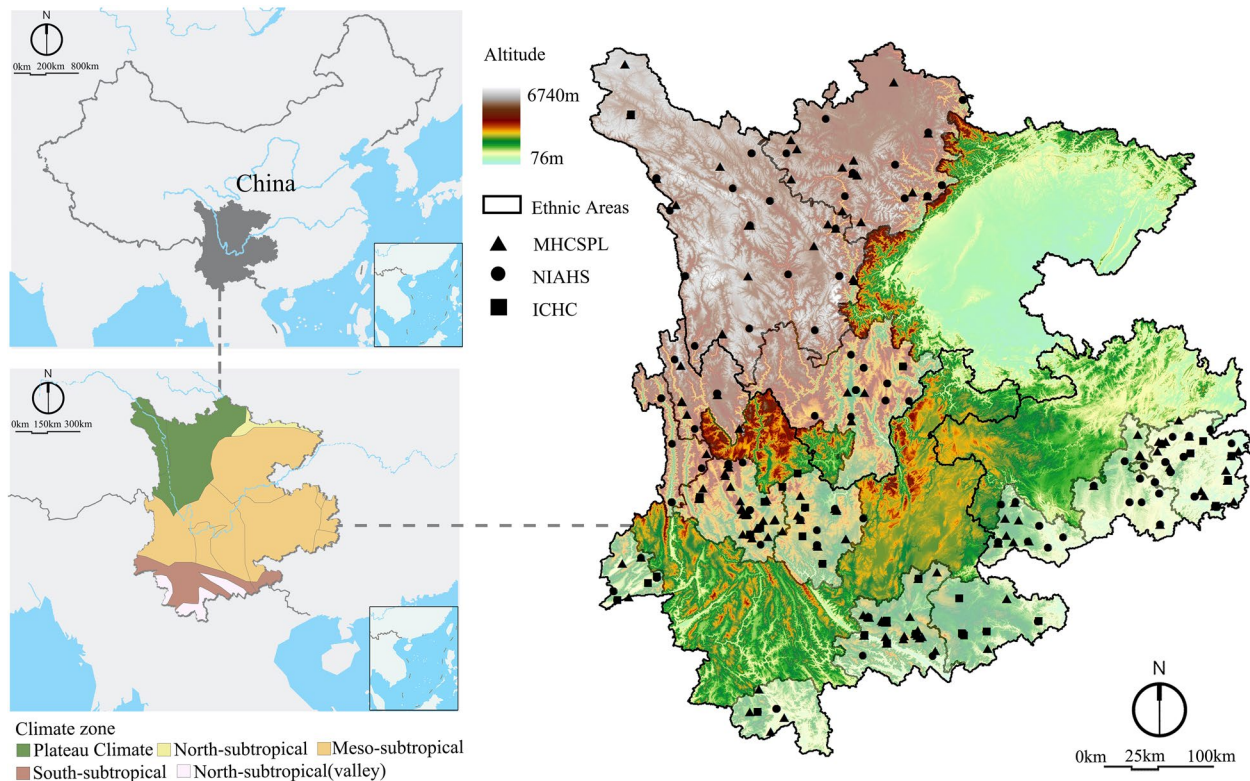
Fig. 1 Topography and climate distribution of the study area

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Table 1 Description of the data in this paper

Name	Data	Source
NIAHS	Locations and attributes of NIAHS in China	http://www.moa.gov.cn, accessed on 10 June, 2023)
MHCSPL	Locations and attributes of MHCSPL in China	http://www.ncha.gov.cn/index.html, accessed on 10 June, 2023)
ICHC	Locations and attributes of ICHC in China	https://www.mct.gov.cn/, accessed on 10 June, 2023)
Natural factors	Annual average temperature (℃) from 2011 to 2020	http://cnki.nbsti.net/CSYDMirror/trade/Yearbook/, accessed on 10 June, 2023), http://stats.yn.gov.cn/tjsj/tjnj/, accessed on 10 June, 2023), http://stjj.guizhou.gov.cn/tjsj_35719/, accessed on 10 June, 2023), http://tjj.sc.gov.cn/scstjj/, accessed on 10 June, 2023)
	Annual average precipitation (mm) from 2011 to 2020	
	Annual sunshine duration (h) from 2011 to 2020	
	Proportion of mountainous area (%)	
	Land area (km^2)	
	Altitude (m)	
	River density (km/km^2)	
Human factors	Per capita gross domestic product (yuan)	http://cnki.nbsti.net/CSYDMirror/trade/Yearbook/, accessed on 10 June, 2023), http://stats.yn.gov.cn/tjsj/tjnj/, accessed on 10 June, 2023), http://stjj.guizhou.gov.cn/tjsj_35719/, accessed on 10 June, 2023),http://tjj.sc.gov.cn/scstjj/, accessed on 10 June, 2023)
	Gross domestic product of agriculture (billion yuan)	
	Industrial gross domestic product (billion yuan)	
	Gross domestic product of the service industry	
	Ethnic minority population from 2011 to 2020	
	Proportion of ethnic minority population (%) from 2011 to 2020	
	Proportion of urban population (%) from 2011 to 2020	
	Railway mileage (km)	
	Road mileage (km)	
	Historical settlement (Number of Ethnic minority characteristic villages, National Historical and Cultural City, National Historical and Cultural Town, National Historical and Cultural Village)	

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k(a_n \frac{x - x_i}{h}) \qquad (1)$$

In Eq. (1), $k(a_n\frac{x-x_i}{h})$ represents the kernel function, h > 0 represents the bandwidth, n is the total number of cultural heritage sites, and (*x-xi*) represents the distance from the estimated point x to the cultural heritage site xi [27].

Nearest neighbor analysis

Nearest neighbor distance analysis in ArcGIS 10.6 is employed to describe the proximity of point features in space. It provides a visual representation of the spatial adjacency relationships of MCH in Southwest China. The formula is as follows:

$$R = r_1 / r_E$$

$$r_E = 1/2\sqrt{n/A} \qquad (2)$$

In Eq. (2), R denotes the nearest neighbor index; r_1 represents the average distance between each point and its nearest neighbor; r_E represents the theoretical nearest neighbor distance. If R = 1, the point feature distribution type is random; if R > 1, it is uniform; if R < 1, it is clustered [41].

Social network analysis

Social network analysis is used to describe the relationship patterns and structural characteristics of MCH distribution in Southwest China, and to explore the similarity of MCH distribution in different minority areas in terms of heritage occupancy, geographical proximity, and cultural diversity. Network density indicates the tightness of the MCH distribution areas by comparing the actual number of connections to the highest possible number of connections. The network density for nodes within an undirected network is mathematically presented as:

$$D = \frac{2E}{N(N - 1)} \qquad (3)$$

In Eq. (3), D represents the network density, serving as a metric for MCH's interconnectivity within an area, E denotes the number of current edges in the network, and N denotes the total nodes present in the network [42, 43].

In addition, degree centrality is used to clarify the status of MCH distribution areas in Southwest China as nodes in the network, and the higher degree of nodes means that they play a key role in cultural exchange and heritage linking. The degree centrality for nodes within an undirected network is mathematically presented as:

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$$DC_i = \frac{k_i}{N-1} \qquad (4)$$

In Eq. (4), DC_i represents the degree centrality of node i; the higher the value, the greater the centrality of the MCH distribution area within the network; k_i represents the degree of node i, which is decided by the number of immediate neighboring nodes; N is the total number of nodes in the network [42, 44].

Geodetector analysis

GeoDetector is a statistical method that utilizes spatial statistics and information theory to characterize the interaction of geographic phenomena. It is used in this study to measure the explanatory power of natural and human factors on the distribution of MCH in Southwest China. The formula is as follows:

$$q = \left(N\sigma^2 - \sum_{h=1}^{L} N_h\sigma_h^2 \right) \Big/ N\sigma^2 \qquad (5)$$

In Eq. (3), N_h and σ_h^2 represent the number and variance of cultural heritage sites in the h-th class, respectively; N is the total number of cultural heritage sites, σ^2 is the variance of all cultural heritage sites; L represents the number of categories of the h-th class of influencing factors. The q value ranges from 0 to 1, with a higher value indicating a stronger explanatory power for the distribution of cultural heritage sites [32].

Research framework

This study concentrates on 483 national cultural heritage sites, exploring the geographical distribution and influencing factors of MCH in Southwest China. We begin by using the Baidu coordinate selector to gather geographical coordinates (longitude and latitude) of all these heritage sites in Southwest China, creating a comprehensive geographical information database. We use ESRI's ArcGIS 10.6 to construct a distinct grid for each of the potential influencing factors such as climate, geography, and humanities. Subsequently, we employ spatial analysis methods such as Kernel Density Estimation and Nearest Neighbor Analysis to identify the general and specific geographic distribution features of MCH. And then conduct a visualization analysis to reflect the interactivity of the minority autonomous prefectures where MCH is located in terms of heritage occupancy, geographical proximity, and cultural diversity. We superimpose the grid diagram of each potential influencing factor onto the geographical distribution of the cultural heritage sites. Finally, GeoDetector is employed to assess the explanatory power, the personal impact, and the interactive

effects of these potential influencing factors on the distribution of MCH sites in Southwest China. It's crucial to note that the same approach was used to evaluate these factors and their combined impact on the distribution throughout the region, as illustrated in Fig. 2.

Results and discussion

Spatial distribution characteristics

MCH in Southwest China is characterized by an "abundance in the south, scarcity in the north" clustering distribution. Kernel density analysis in ArcGIS reveals the spatial distribution characteristics of MCH, which can be classified into five levels based on the natural breakpoints method. Figure 3 shows that MCH is unequally distributed in space, with significant regional differences. It consists of two core-density regions, one medium-density region, and several secondary-density regions. The two core density regions, located in northern Yunnan and southeastern Guizhou, account for 23.12% of the total number of MCH sites each, while the medium-density region and its extended clusters cover 13.12% of MCH sites primarily distributed in southeastern Yunnan. It is noteworthy that despite the expansive land area of Ganzi and Aba in northwest Sichuan, the distribution of MCH is relatively scattered. MCH sites make up a mere 12.2% of the total land area, amounting to 33.36%.

In terms of type distribution, the nearest neighbor index indicates that the distributions of MHCSPL, ICHC, and NIAHS display clustering characteristics (Table 2). An in-depth examination of the point kernel density in ArcGIS indicates that the three types of MCR in Southwest China have a high-density cluster of characteristics. Dali and Honghe in Yunnan make up 16.60% of MHCSPL, Qiandongnan in Guizhou accounts for 6.60% of ICHC, and Dali in Yunnan accounts for 16.60% of NIAHS. In addition to these prominent distribution areas, the remaining areas show a medium and low-density dispersion of various heritage types (Fig. 3).

As shown in Fig. 4, the network density index in social network analysis demonstrates tight connections and hierarchical differences among various municipal areas regarding MCH distribution in three key dimensions: geographical proximity (48.90%), heritage occupancy (47.25%), and cultural diversity (46.15%). Specifically, nodes with a high degree centrality (all > 80.00) establish the core of the regional network and play a critical role in linking the regional heritage sites. For example, the core area of the geographical proximity network is composed of Liangshan and Chuxiong, the core area of the heritage occupancy network is composed of Qiandongnan and Dali, and the core areas of the cultural diversity network is composed of Dali and Chuxiong. On the other hand,

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1.Data Preparation
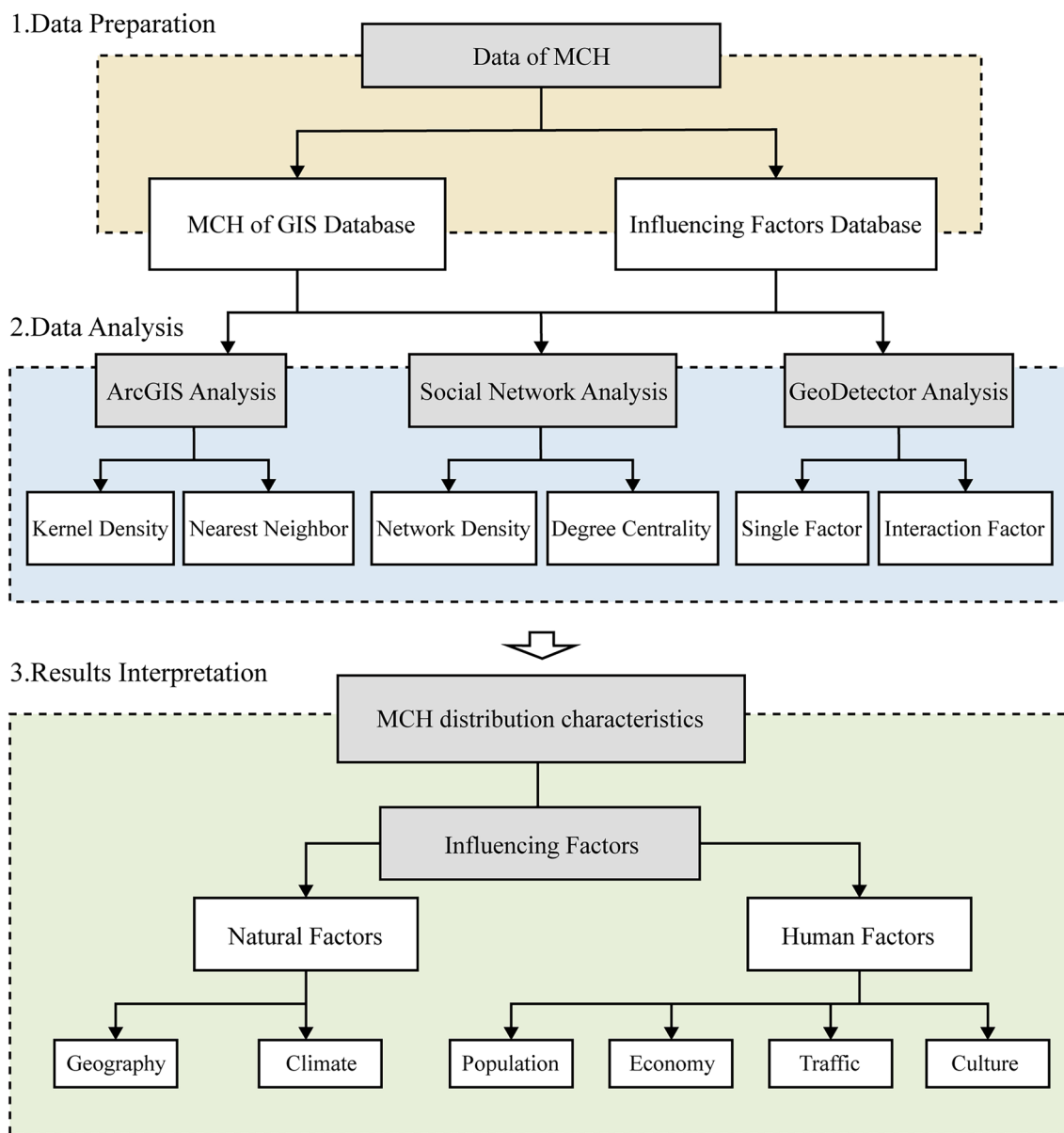
Fig. 2 A flowchart as a schematic representation of the research framework

areas with lower degree centrality show relatively weak influence in regional connections. For example, in the geographical proximity network, as well as in the heritage occupancy and cultural diversity networks, Qiandongnan and Nujiang respectively occupy a marginal status. Generally, Dali and Chuxiong take up the dominant position in the heritage relationship networks of MCH distribution, whereas Nujiang and Xishuangbanna are in marginal positions.

Statistics reveal a marked disparity in the allocation of MCH among ethnic communities in Southwest China. The Yi and Tibetan ethnic groups have the most MCH sites, accounting for 23.12% of the total, while the Jingpo ethnic group has the least number of MCH sites, accounting for only 23.12%. Specifically, the Yi (23.12%), Tibetan (23.12%), and Bai (23.12%) ethnic groups make up 70.1% of MHCSPL, while the Jingpo ethnic group has no MCH sites. The Miao (23.12%), Tibetan (23.12%), and Yi (23.12%) ethnic groups comprise 54.6% of the ICHC, whereas the Jingpo ethnic group accounts for only 23.12%. approximately 43.1% of NIAHS is comprised of the Bai ethnic group, while the Qiang, Buyi, Lisu, and Jingpo ethnic groups lack agricultural heritage. In general, the Yi and Bai
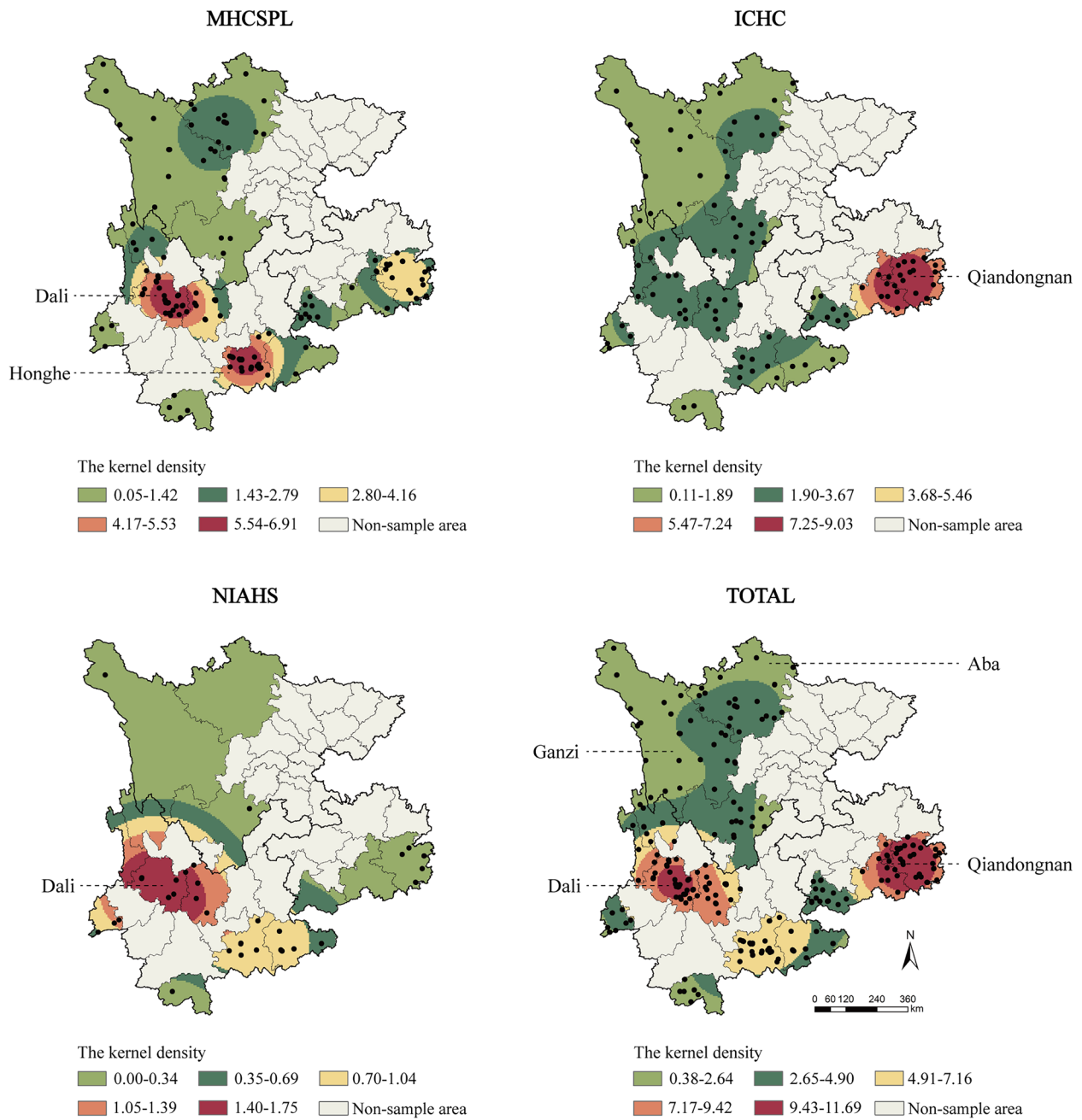
Fig. 3 Kernel density estimation of MCH in Southwest China

Table 2 The nearest neighbor index of MCH in Southwest China

Type	Average observation distance (km)	Expected average distance (km)	Average nearest neighbor index (*R*)	Clustering pattern
MHCSPL	6.38	28.19	0.226201	Clustered
ICHC	10.43	27.74	0.224865	Clustered
NIAHS	20.13	54.84	0.381853	Clustered

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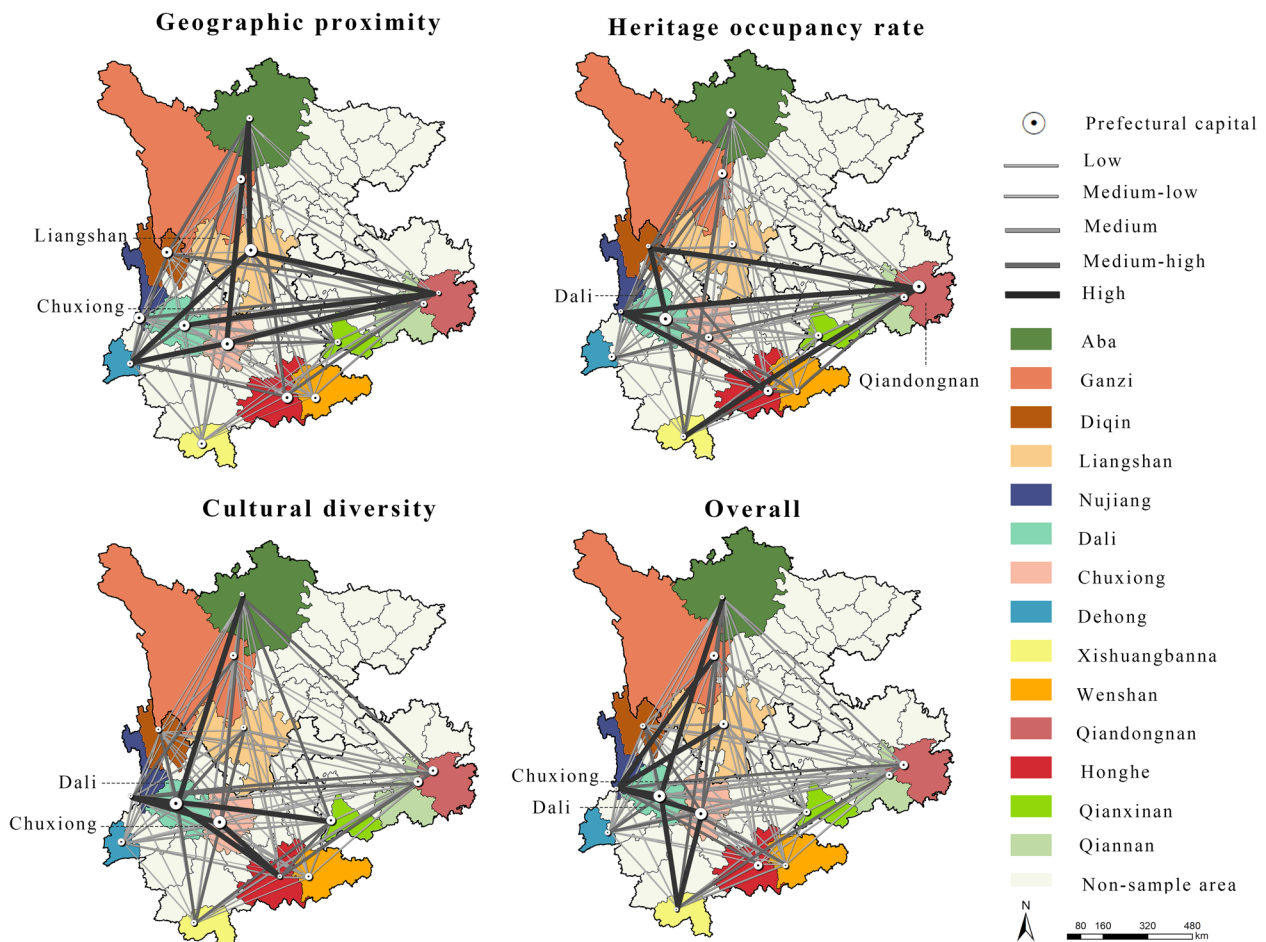
Fig. 4 Social Network Analysis of MCH in Southwest China

ethnic groups possess distinct advantages in terms of the diversity and quantity of MCH, whereas the Qiang, Hani, Zhuang, Lisu, and Jingpo ethnic groups are comparatively deficient (Fig. 5).

Influencing factors

Figure 6 and Additional file 1: Table A1 present the results of the q statistics calculated by GeoDetector for each influencing factor on the distribution of MCH in Southwest China. All measurement results are less than 0.01, indicating the significance of all influencing factors. Overall, human factors exhibit a greater impact on the distribution of MCH in Southwest China compared to natural factors. The explanatory power of all evaluation indices, except for annual average temperature and annual average precipitation, for human factors exceeds 0.4. In contrast, natural factors have explanatory power below 0.4. Specifically, the natural factors with the strongest explanatory power for the spatial distribution of MCH in Southwest China, from highest to lowest,

are the proportion of mountainous area, annual average sunshine, river density, land area, elevation, annual average precipitation, and annual average temperature. The human factors with the highest explanatory power, also from highest to lowest, are the proportion of minority population, urbanization rate, highway mileage, railway mileage, number of minority populations, GDP of the primary industry, per capita GDP, number of historical settlements, GDP of the secondary industry, and GDP of the tertiary industry.

The results of the interaction factor analysis indicate that the explanatory power of both natural and human factors on the distribution of MCH in Southwest China is not independent, as evidenced by the fact that the explanatory power of all factor interactions is greater than 0.4. Instead, they demonstrate combined and non-linear effects. The explanatory power of factor interactions with two-factor enhancement exceeds the explanatory power of any single factor. For instance, the factor interaction between the proportion of mountainous area and other

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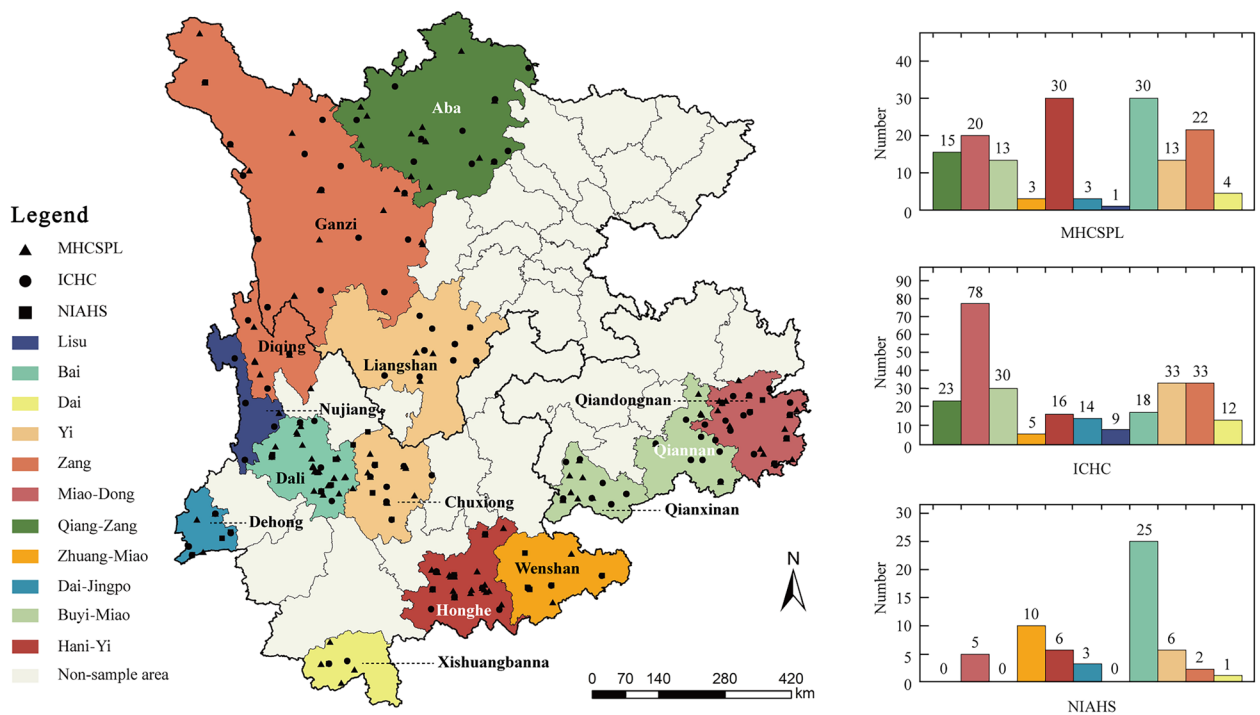
Fig. 5 Distribution of MCH among ethnic settlements in Southwest China

natural and human factors exhibits a q value greater than 0.9, surpassing the explanatory power of all single-factor analyses. The occurrence of non-linear enhancement arises when the explanatory power of factor interactions compasses the sum of the explanatory powers of their respective individual effects. As an example, the q value of the factor interaction between urbanization rate and other human factors exceeds 0.6, surpassing the sum of the explanatory powers of the individual factors. Consequently, most factors demonstrate both two-factor enhancement and non-linear enhancement interactions with other factors. An example is the factor interaction between river density and other factors, which exhibits both two-factor enhancement and non-linear enhancement effects, with q values exceeding 0.7 (Fig. 7, Additional file 1: Table A2.

Natural factors

When compared to the northern part of China [31], the mountainous area of Southwest China has the greatest explanatory power for the distribution of MCH, both in single-factor and interaction factor analyses. Yunnan, Guizhou, and Sichuan ethnic minority areas are characterized by their mountainous terrain, which has led to the formation of cultural heritage sites such as terraces, tea gardens, rock paintings, and ancient tombs. Mountainous areas with undulating topography are conducive

to the generation of MCH, resulting in denser distributions of MHCSPL and NIAHS. For instance, Wenshan (86.16% mountainous area) and Dali (71.97% mountainous area) comprise 60.3% of NIAHS, while Qiandongnan (85.97% mountainous area), Honghe (72.76% mountainous area), and Dali (71.97% mountainous area) account for 51.9% of MHCSPL. Regions characterized by a lower percentage (e.g., Nujiang 25.97%) and a higher percentage (e.g., Qiandongna 89.77%) of mountainous areas have fewer MHCSPL and NIAHS resources. Areas with high levels of human activity, labor-intensive economies, and substantial development may generate more MCH but face challenges in terms of protection. Conversely, areas with higher proportions of mountainous areas are more suitable for conservation. In contrast to MHCSPL and NIAHS, ICHC remains relatively unaffected by the presence of mountainous areas, owing to the distinctive attributes of intangible cultural heritage (Fig. 8).

The distribution of MCH in Southwest China can be largely attributed to land area, though it is not as influential as in mountainous areas. Regions with larger land areas in ethnic minority regions tend to have overlapping multi-ethnic areas and a greater number of cultural heritage sites. For example, Aba (151,100 km^2) and Ganzi (83,200 km^2) are home to a wide range of ethnic music heritage, such as Xianzi dance, Guozhuang dance, Qiang flute, Pi drum dance, and Tibetan opera, with 23–25

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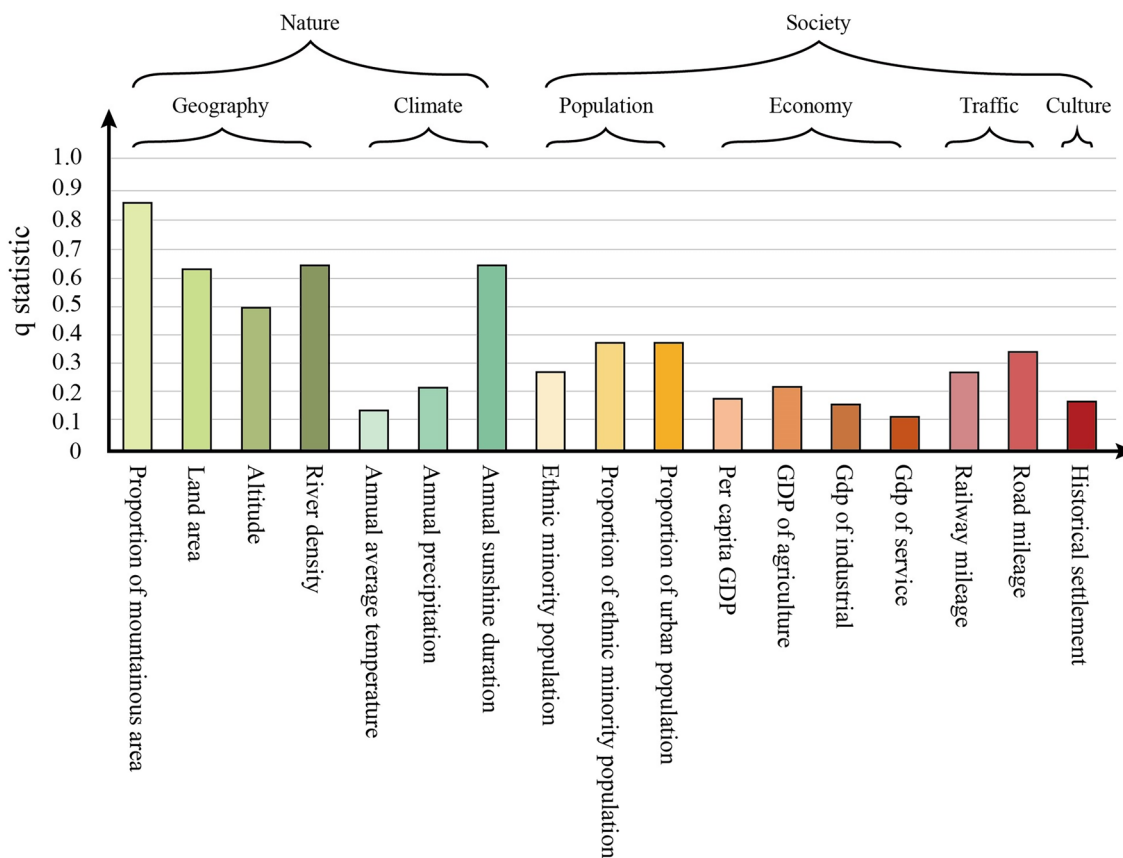
Fig. 6 The results of single factor analysis for MCH distribution

ICHC items, respectively, making them among the top regions in all ethnic areas (Fig. 8).

Elevation also exhibits strong explanatory power for the distribution of MCH in Southwest China. Lower elevations are more conducive to the generation of various types of cultural heritage, while higher elevations are drier and more suitable for preserving tangible cultural heritage. The former is represented by Qiandongnan (with an average elevation of 766.06 m), while the latter is represented by Dali (with an average elevation of 2,243.46 m), both of which are regions with the accumulation of various cultural heritage. Tibetans and Qiang ethnic groups reside in high-altitude regions (>3,000 m), while Miao, Dong, Zhuang, and Dai ethnic groups, among others, inhabit mid-altitude regions (1000–3000 m), which boast abundant cultural heritage and traditional knowledge (Fig. 8).

River density and annual average sunshine demonstrate significant explanatory power for the distribution of MCH in Southwest China. The presence of dense water systems and ample sunshine contribute to the growth of agricultural and animal husbandry, ensuring a stable livelihood for ethnic groups. Consequently, areas with plentiful water resources, ample sunlight, prosperous economies, and larger populations exhibit a higher prevalence of MHCSPL and NIAHS [32, 45, 46]. However, the single-factor analysis of annual average temperature and annual precipitation does not provide a strong explanation for the distribution of MCH in Southwest China. When combined with other factors, it shows a stronger explanatory power in interaction factor analysis. For example, Qiandongnan in Guizhou has a river density of 10.23%, annual average sunshine of 1,170.22, annual average temperature of 16.41 °C, and annual average precipitation of 1,287.14 mm, while Dali in Yunnan has a river density of 12.02%, annual average sunshine of 2,449.26, annual average temperature of 16.53 °C, and annual average precipitation of 742.02 mm. The presence of these interactive natural factors contributes to the accumulation of MCH in these regions (Fig. 8).

Human factors

This study examines the influence of contemporary human activities on MCH in the Southwest region of China. The distribution of MCH can be strongly explained by the number and proportion of minority

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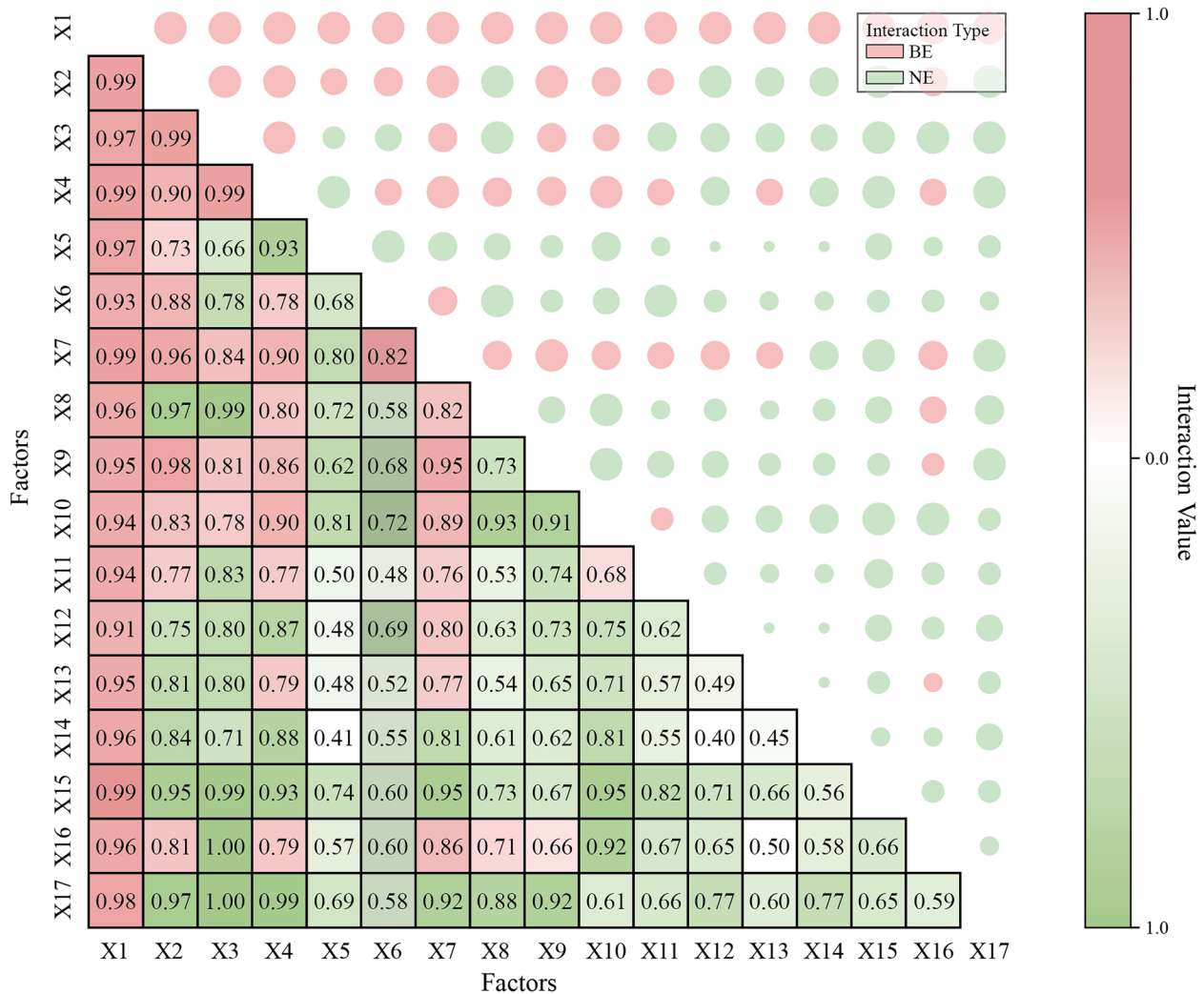
Fig. 7 The results of interaction factor analysis for MCH distribution. *NE* nonlinear enhancement, *BE* bi-factor enhancement. X1: Proportion of mountainous area; X2: Land area; X3: Altitude; X4: River density; X5: Annual average temperature; X6: Annual precipitation; X7: Annual sunshine duration; X8: Ethnic minority population; X9: Proportion of ethnic minority population; X10: Proportion of urban population; X11: Per capita GDP; X12: GDP of Agriculture; X13: GDP of Industrial; X14: GDP of Service; X15: Railway mileage; X16: Road mileage; X17: Historical settlement

populations, as population size and regional population advantage are essential for the preservation of traditional ways of life and production [2, 31, 32]. This is particularly crucial for ICHC and NIAHS, as they require dynamic heritage inheritance. In Qiandongnan, for instance, the proportion of the minority population accounts for 81.16% and the total number of MCH sites is 103, while in Qianxinan, the percentages are 38.37%–23%, respectively, indicating a significant disparity in numbers (Fig. 9).

The distribution of MCH in Southwest China can be strongly explained by the urban population proportion and transportation indicators (i.e., highway mileage, railway mileage). Excessive urbanization and dense transportation networks often disrupt MCH sites through contemporary human activities, such as occupying arable land, resulting in the loss of agricultural labor, and altering traditional ways of life. Analysis reveals that the urbanization rate in ethnic minority areas of Southwest China ranges from 25.29% to 43.51%, and highway mileage ranges from 16.82 km/100 km^2 to 134.54 km/100 km^2, considerably lower than in developed regions. This could account for why MCH is considered to be of higher preservation quality in the past. For instance, Qiandongnan boasts an urbanization rate of 25.86% and a highway mileage of 86.65 km/100 km^2, while Shanghai, the most developed area in China, exhibits respective percentages of 89.30% and 184.06 km/100 km^2 (Fig. 9).

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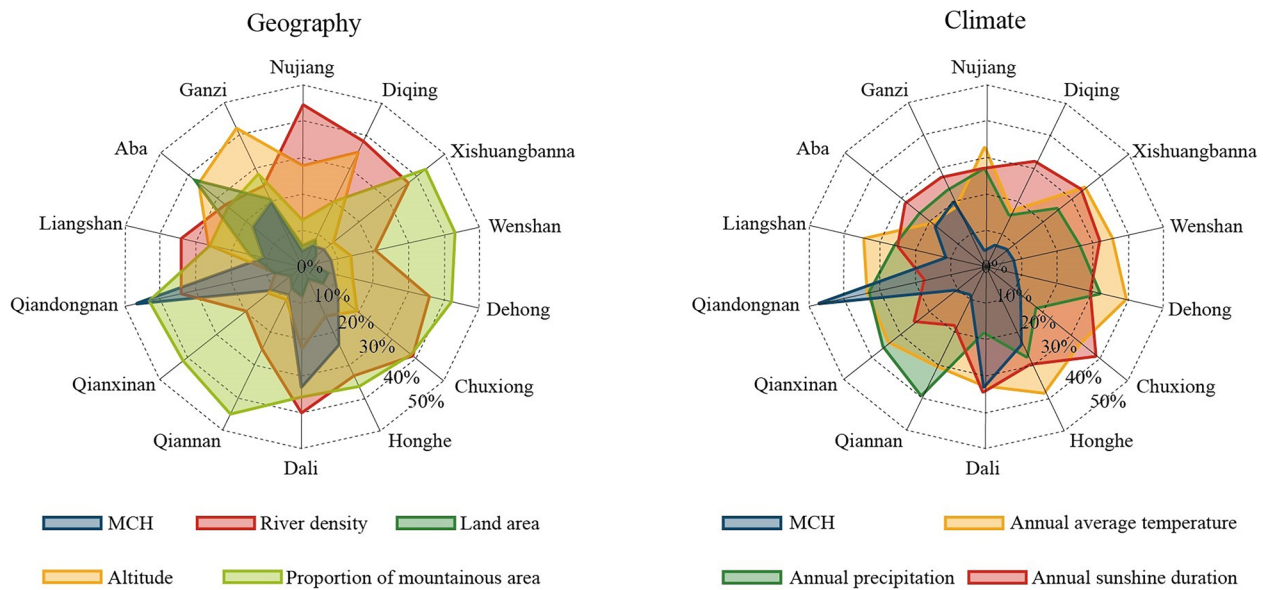
Fig. 8 The relationships between MCH and natural factors

The economic factors (per capita GDP, GDP of the primary industry, GDP of the secondary industry, and GDP of the tertiary industry) have a certain explanatory power for the distribution of MCH in Southwest China. Positive influences arise from economic support and the endogenous driving force of ethnic characteristic agricultural products, cultural tourism, and industrial benefits, which contribute to the protection and continuity of various types of MCH [47, 48]. Industrial development driven by the economy has had a negative influence on the traditional lifestyles and production practices of ethnic minority regions [22]. The analysis shows that per capita GDP in the ethnic minority areas of Southwest China varies between15,166 yuan and 61,849 yuan, while the ratio of agricultural, industrial, and service sector GDP is approximately 1:2:2. The utilization of agricultural, forestry, fishery, and animal husbandry products remains crucial in protecting a wide range of cultural heritage sites (Fig. 9).

Cultural factors, represented by the number of historical settlements at various levels, provide a favorable cultural ecosystem for the continuity of MHCSPL, ICHC, and NIAHS. However, their explanatory power for the distribution of MCH in Southwest China is mainly due to the combined effects of geographic, climatic, and population indicators through interaction. The explanatory power of individual effects of historical settlements at various levels is relatively low (Fig. 4). The dispersion of multiple MHCSPL sites across ancient sites, ancient tombs, cave temples, and

similar types can be ascribed to this. The disappearance of many native historical settlements that are closely related has caused a decrease in the relationship between the overall distribution of MCH and cultural factors (Fig. 9).

Combined impact

Geographic detector analysis reveals that the distribution patterns of MCH are determined by the lifestyles and production methods of nomadic and agrarian ethnic minorities. The Tibetan ethnic group is representative of nomadic ethnic minorities. Their MHCSPL is characterized by dispersed religious buildings, their ICHC is primarily characterized by music and dance, while NIAHS is less common due to the transient settlement patterns. The Dong and Bai ethnic groups are representatives of agrarian ethnic minorities. Their MHCSPL is characterized by concentrated clusters of residential buildings, their ICHC is characterized by folk customs and traditional craftsmanship, and a large number of NIAHS sites highlight the enduring relationship between these ethnic groups, land, and sustainable agricultural practices.

Additionally, in line with cultural ecosystem theory, the differences in human geographical environments in patch-corridor-matrix pattern determine the typology, quantity, and spatial distribution of MCH. In practical terms, the development of NIAHS is intimately related to the patch characteristics of natural landscapes, the preservation and dissemination of ICHC hinge on the connectivity of cultural corridors, whereas

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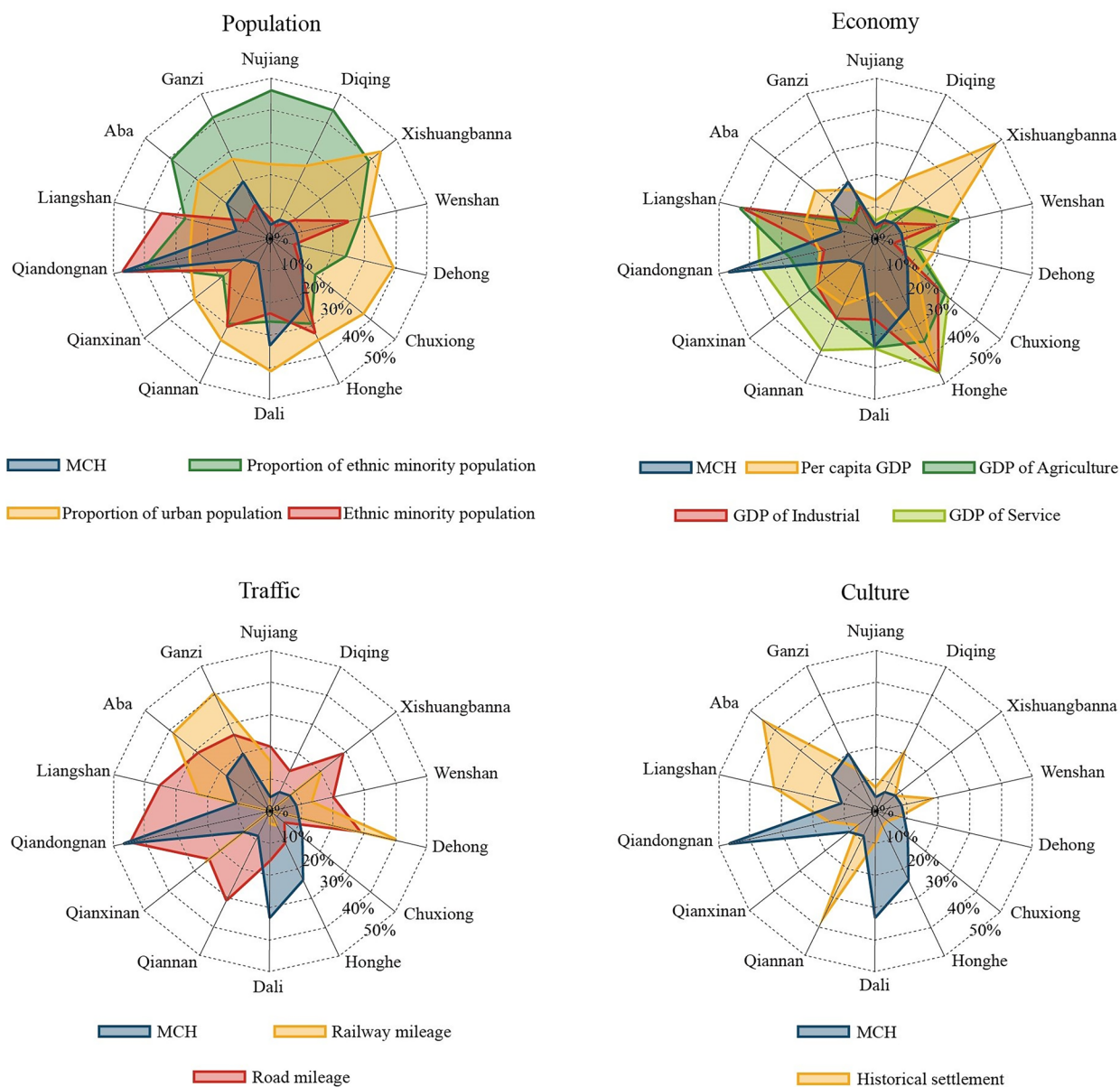
Fig. 9 The relationships between MCH and human factors

the distribution of MHCSPL reflects the collaborative interplay between environmental and cultural matrices.

Research contributions and limitations

This study provides insights into the distribution characteristics of MCH in Southwest China and offers a systematic comprehension of the primary influencing factors through a robust and versatile model. In contrast to prior investigations focused on the generation and interpretation of ethnic heritage value (e.g., anthropology and sociology studies) [16, 20], we provide

visual representations and scientific evidence regarding the geographical features of ethnic minority cultural heritage. This constitutes the original contribution of this study, with potential application in various fields.

Another contribution of this study is overcoming the constraints of previous research that focused on the distribution of individual cultural heritage categories. Previous studies have concentrated on cultural heritage classified according to the UNESCO binary division (tangible and intangible) [49] or have conducted specific investigations into the Globally Important Agricultural Heritage Systems (GIAHS) as defined by FAO [5,

6]. These studies failed to take into account the comprehensive role that these heritage types play in the ethnic minority cultural heritage system. By considering the contributions of all types of heritage, the added value surpasses the sum of the contributions made by individual types.

The study uncovers the clustering characteristics of MCH based on regional, type, and ethnic distributions in Southwest China, as well as the systematic explanations of natural and contemporary human factors on the distribution patterns of MCH. Addressing these matters can furnish local governments and management departments with scientific guidance on the discovery, assessment, and protection of MCH. On one hand, by considering the spatial coupling relationship between MCH clusters and various influencing factors, the Chinese government can protect MCH in Southwest China through cross-regional holistic approaches. For example, a national-level Cultural Reserve or Heritage Corridor can be established for the Tibetan-Yi "Zangyi Corridor" in the western part of Sichuan, western Yunnan, and the transverse range of the Hengduan Mountains, and the Nu River, Lancang River, Jinsha River, Yalung River, Dadu River, and Min River regions, to avoid the cultural ecological chain being broken by single-type management and territorial fragmentation. On the other hand, it is necessary to fully consider the crucial role of heritage network hubs such as Dali and Chuxiong in regional heritage linkages and to promote regional interaction of MCH in Southwest China through their agglomeration and spillover effects in heritage protection and heritage tourism. Furthermore, particular strategies for digital preservation and online museum models can be adopted in areas with weaker heritage networks and scattered MCH distributions. Overcoming geographical constraints to improve the efficiency of protecting and sharing cultural heritage.

Although the study of spatial characteristics and influencing factors of three types of cultural heritage contributes to the sustainable development of MCH in Southwest China, some limitations that require addressing in future research. The primary focus of this study is to analyze the spatial patterns and clustering analysis of 483 MCH sites. Nevertheless, it lacks exploration of the temporal sequence that reflects the core values of MCH. To achieve a more comprehensive understanding in future research, the study should consider spatiotemporal interaction patterns of MCH distribution. Secondly, a macro-level analysis of MCH distribution and the influencing factors that shape it in Southwest China is undertaken. The economic, cultural, social, and political impacts of MCH on the territoriality of ethnic minority regions have yet to be explored, given the limitation of paper length. These aspects are

relevant to the contemporary values of MCH and warrant further investigation. In future research, in addition to the aforementioned aspects, the preservation of dynamic MCH and the disciplines of sustainable development should be further developed.

Conclusion

This study analyzed the distribution characteristics of Minority Cultural Heritage (MCH) in Southwest China and its relationship with influencing factors using various spatial analysis methods, mathematical statistics, and Geodetector. The key findings are as follows:

(1) The spatial distribution of MCH resources in Southwest China exhibits an agglomeration pattern, with a higher density in the south and a lower density in the north. Honghe, Dali, and Qiandongnan serve as the core areas of high-density MCH concentration.

(2) The spatial distribution of MCH resources in Southwest China exhibits an agglomeration pattern, with a higher density in the south and a lower density in the north. Honghe, Dali, and Qiandongnan serve as the core areas of high-density MCH concentration.

(3) The spatial distribution of MCH resources in Southwest China exhibits an agglomeration pattern, with a higher density in the south and a lower density in the north. Honghe, Dali, and Qiandongnan serve as the core areas of high-density MCH concentration.

(4) The spatial distribution of MCH resources in Southwest China exhibits an agglomeration pattern, with a higher density in the south and a lower density in the north. Honghe, Dali, and Qiandongnan serve as the core areas of high-density MCH concentration.

Abbreviations

GIS	Geographic information system
MCH	Minority cultural heritage
MHCSPL	National key cultural relics protection units
ICHC	Intangible cultural heritage of china
NIAHS	National important agricultural heritage system

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40494-024-01230-4.

Additional file 1: Table A1. The results of single factor analysis for MCH distribution. **Table A2.** The results of interaction factor analysis for MCH distribution.

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Declarations

Ethics approval and content to participate

Not applicable.

Competing interests

The authors declare no competing interests.

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