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Acta hort regiotec, 25, 2022(1): 8–20
DOI: 10.2478/ahr-2022-0002

Research Article

Comprehensive zoning scheme for vernacular landscapes of China

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Article Details: Received: 2021-12-23 | Accepted: 2022-02-02 | Available online: 2022-05-31

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As China's rapid development has gradually expanded beyond urban areas, vernacular landscape as a significant expression of local conditions receives more and more attention. This paper aims to formulate a comprehensive zoning scheme for vernacular landscapes of China. The zoning applies zoning methods and technical means of the Geographic Information System. Based on the understanding of the vernacular landscape concept, the main factors that determine the feature of the vernacular landscape are identified, including landforms, climate, hydrology, vegetation, land use, settlements, housing, population, economy, and customs. Then, the indicators that can significantly reflect the characteristics of each factor are selected to construct an indicator system for comprehensive zoning. We combine quantitative and qualitative analysis to examine the spatial differentiation patterns of Chinese vernacular landscapes comprehensively. The prior zoning principle is a combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape. Simultaneously, it considers the combination of the principles of synthesis and dominant factors, the combination of the principles of top-down and bottom-up, the combination of the principles of spatial integrity and continuity, and the principle of hierarchical zoning. Based on indicator evaluation and essential zoning basis, using overlay analysis and comparative analysis methods, the country is divided into two-grade spatial units of vernacular landscapes by two steps: 8 vernacular landscape regions and 56 vernacular landscape sub-regions. It provides theoretical support for protecting and developing vernacular landscape characteristics, and exerting regional advantages to achieve comprehensive development.

Keywords: spatial differentiation, zoning principles, indicator system, Chinese vernacular landscape regions, Chinese vernacular landscape sub-regions

1 Introduction

In recent years, with the implementation of a series of national macro strategies – such as the "Beautiful China" Construction, Regional Sustainable Development, and Rural Revitalization Strategy, China's rapid development has gradually expanded beyond urban areas. Vernacular landscape, as a significant expression of local conditions, receives more and more attention. In addition, it is necessary to identify landscape patterns from a regional and integrated perspective in response to the current national spatial planning.

Geographical zoning or classification is the division of geographical entities based on properties or relationships (Chorley & Haggett, 1967; Johnston, 1968). Synthesis is the basis for the existence of geography and the fundamental way to understand the geographical environment dialectically (Zheng et al., 2005). Besides, comprehensive geographical zoning is compatible with the requirements of socio-economic development. Hence, since the 1990s, in the face of rapid changes in the ecological environment and socio-economic situation, some Chinese scholars have realized the importance of zoning integrating natural and social aspects and have conducted many comprehensive geographical zoning practices, such as the land use zoning scheme of China (Feng, 2001), the comprehensive regionalization of human geography in China (Fang et al., 2017), and the zoning by rural regional system types (Liu, Zhou & Li, 2019b), etc. However, there are only a few comprehensive zoning studies involving cultural features, which may be due to the diversity and complexity of the culture itself.

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So far, most landscape zoning has been carried out from the perspective of landscape ecology based on the theory of landscape heterogeneity (Center, 2008; Fu et al., 2001; Liu et al., 2019a; Long, Nelson & Wulder, 2010). These studies emphasize the spatial differentiation of natural spaces, ecological processes, and landscape functions (Li et al., 2006b) without considering the landscape's socio-cultural attributes. In short, there is still a lack of landscape regionalization studies that integrate natural and human factors, especially vernacular landscapes.

This paper aims to formulate a comprehensive zoning scheme for vernacular landscapes of China, seeking a comprehensive understanding of differentiation patterns of Chinese vernacular landscapes. The research focuses on three main aspects: the stability and differentiation of the natural geographical environment, the inheritance and characteristics of the socio-cultural background, and the combination of the principles of the relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape. Our findings will provide a scientific basis for the development of Chinese vernacular landscapes regarding preserving local styles, inheriting cultural traditions, and protecting the ecological environment.

1.1 Literature review

According to Kwa (2005), the word "landscape" can be traced back to Dutch as a loan word into the English language along with a fair amount of landscape paintings imported from Holland and Flanders, referring to rural settlements with the administrative implication (Ogden, 1955). However, the meaning of the word "landscape" evolved to describe a pictorial representation by the end of the sixteenth century, firstly as the background of a historic piece, then as an independent genre. Since then, "landschap" is an expression representing the land, mostly as inhabited by humans (Fechner, 1986). The roots of "landscape" in Anglophone geographic practice are to be found in the German concept of "landschaft", which means the sense of visual aesthetics, emphasizing people's perception and cognition of natural scenery, without clear space boundaries (Cosgrove, 2004). Humboldt developed the concept of "landscape", transforming it from an aesthetic category into an abstract entity representing the overall characteristics of certain land on the earth (Humboldt, 1969; Pagden, 1993). From a geographic perspective, Schmithüsen (1973) believes that landscape is relative unity, stepwise integrated local systems of factors comprising all realms of nature. Thus, from natural sciences to human sciences, different disciplines have different understandings of landscape (Hersperger et al., 2020). Today, the common understanding of "landscape" is consistent with the definition in the European Landscape Convention (2000): "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors." The landscape represents the imprint of complex physical geographical processes and human historical activities on the earth (Li, 2007). Therefore, the concept of "landscape" can be used to draw connections among people, between people and places, and between societies and their environment (Bloemers et al., 2010).

Jackson earlier applied "vernacular" to landscapes generated by everyday praxes, which are dedicated to stability and history, and elaborated on "vernacular landscape" as a basic form of cultural landscape (Jackson, 1984). Linking the attribute "cultural" to landscape underlines the holistic view of landscapes: humans interact with landscapes in dynamic processes (Naveh, 1995). Vernacular landscape refers to "the adaptation method adopted by local people to the natural process, the land, the spatial patterns for life; the manifestation of the life way of the people here and now on the earth; a regional complex including the land, towns, settlements, dwellings, temples, etc. on the land; a whole system including nature, history, and culture" (Yu, Wang & Huang, 2005). Vernacular landscape reflects the physical geography and humanistic features of a particular area and the interface between time and space, nature and culture, tangible and intangible assets.

1.2 Theoretical framework

The vernacular landscape includes not only the landscape formed by natural processes but also the landscape formed by the transformation of nature by human activities during history, as well as the unique local cultural assets. Therefore, from the comprehensive perspective of the overall characteristics, vernacular landscape is a unity constituted by natural conditions and human production and lifestyle in a particular area.

Natural constituents of the vernacular landscape

The natural environmental factors significantly influence and characterize vernacular landscapes, mainly manifested in tangible landscapes. Out of them, landforms are the critical basis, reflecting the characteristics and boundaries of the regional environment, and the general topography is the main factor constituting the landscape. Climate is a prerequisite for the formation of vernacular landscapes, which provides natural nutrients and energy and is critical for landscape expression. Surface hydrological processes play a significant role in the development of spatial patterns and the appearance of vernacular landscapes. Vegetation is an indispensable part of the natural ecosystem, and it is also an essential

factor that best reflects the degree of human transformation to nature. Diverse vegetation is an important and distinctive factor of vernacular landscapes (Li & Guo, 2015). In summary, the landforms, climate, hydrology, and vegetation are the main factors of the geographical patterns and the vernacular landscape ecosystem.

Human constituents of the vernacular landscape

Throughout history, the human impact on nature has also played a dominant role in developing vernacular landscape. Vernacular landscape includes not only the tangible but also the intangible human heritage. Altogether they provide vernacular landscape a unique appearance. The tangible landscape is characterized by various factors at different spatial levels, including macro, meso, and micro levels. Land use determines the overall image of the vernacular landscape, embodying the law of land evolution, the process of resource utilization, and the way of interaction between man and nature at a macro level. The distribution of villages is a vital characteristic of the vernacular landscape, reflecting the settlement status of diverse concentrations based on geographical conditions at a meso level. The housing style is the fundamental physical representation of vernacular landscapes, reflecting the common humanistic characteristics of a particular area at a micro level. Out of the intangible landscape, the population, that is, the man has always been the base for the formation and existence of vernacular landscapes. The economy is the thing that human beings are engaged in daily life to meet the needs of human society; therefore, it is an essential aspect of vernacular landscape. The traditional custom is the matter formed by historical memory and cultural awareness of local areas and is the spirit of the vernacular landscape. Popular local customs have a robust humanistic colour, rich content, and strong influence, which can be regarded as a critical feature of vernacular landscape (Liu, 2013). In summary, land use, settlements, housing, population, economy, and customs are the main human factors of the vernacular landscape. They reflect the human-landscape relationship in the vernacular landscape and are relatively stable landscape factors (Fig. 1).

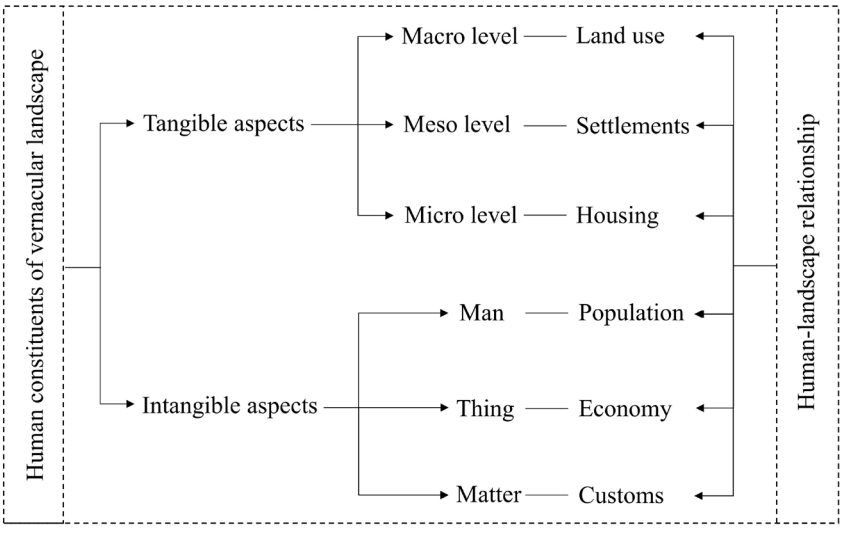


Figure 1 The relationship of the human factors constituting vernacular landscape

Spatial differentiation of the vernacular landscape

The natural environment itself is diverse, and it is also the basis of the diversity of human cultures. The two together form different landscape patterns, leading to an apparent disparity between various areas so that vernacular landscapes show distinctive local characteristics. To clearly and fully understand the differentiation law of vernacular landscapes, it is necessary to introduce the concept of region, that is, to designate spatial units of vernacular landscapes. In this study, the concept of "vernacular landscape region" emphasizes the relativity of the zoning results while highlighting the consistency of the regional natural and human conditions.

2 Material and methods

2.1 Indicator system of Chinese vernacular landscapes

The indicator system is the basis and core of geographical zoning. Based on the research focus, the regionally comparable and easy-to-operate indicators should be selected to construct an effective indicator system to ensure the scientificity, integrity, and non-overlapping of geographical zoning. According to the main factors of natural constituents and human constituents of vernacular landscape, we select the indicators that can significantly reflect the characteristics of each factor to build the indicator system for comprehensive zoning of Chinese vernacular landscape (Table 1).

Among them, the indicator data of natural factors of vernacular landscape comes from the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn/) and the National Geomatics Center of China (http://www.ngcc.cn/). The data on the ratio of the non-aging population (under 65 years

Table 1 Indicator system for comprehensive zoning of Chinese vernacular landscapes

Level	Factor	Indicator	Basis
Natural constituents of vernacular landscape	landforms	altitude (m)	– landforms greatly contribute to the spatial differentiation of the natural environment (Cheng et al., 2019). Areas with different landforms show distinct landscape patterns and appearances. The altitude is an intuitive sign of the macro-morphological characteristics of landscapes
	climate	average temperature (°C), average rainfall (mm)	– climate is related to most natural processes, which is crucial for the evolution of landscapes. Besides, the climate phenomenon itself can be taken as a kind of vernacular landscape. Average temperature and rainfall conditions can reveal the differentiation law of natural zones (Zheng & Fu, 1999)
	hydrology	river density ($km.km^{-2}$)	– hydrology is a fundamental element that affects the settlement environment. As one of the essential indicators of the characteristics of the watershed structure (Huang, Xu & Chen, 2001), river network density matters in the regional differences of vernacular landscapes
	vegetation	net primary productivity ($g.C.m^{-2}$)	– vegetation is considered a great indicator of regional natural differentiation, and therefore a necessary feature to identify landscapes. As a critical parameter of the vegetation ecosystem, the average net primary productivity can reflect the overall spatial distribution of vegetation (Piao, Fang & Guo, 2001)
Human constituents of vernacular landscape	land use	land use type	– land use or land cover change is the most closely intersected issue between natural and human processes in global environmental changes (Li, 1996). Under the constraints of specific physical geography, social economy, and human history, diverse types of land use areas have been formed (Feng et al., 2010)
	settlements	administrative village density (per ten thousand km^2)	– settlement distribution is a record of long-term adaptation and interaction between man and land and thus an essential part of vernacular landscape. Administrative village density embodies multiple connections between residents and the environment among regions
	housing	traditional dwelling type	– housing is a fundamental symbol of vernacular landscape and is regarded as its most direct identifying factor. Under the joint effect of natural geographical environment and the socio-cultural background, various traditional Chinese dwellings reveal prominent vernacular characteristics (Sha, 1998)
	population	ratio of non-aging population (under 65 years old) (%)	– population distribution has influenced the formation and existence of diverse vernacular landscapes in the long run. Due to the imbalance of regional resource conditions and social economy, the ratio of non-aging population varies across the country
	economy	ratio of agricultural industry structure (%)	– economy is an essential field constituting human activities as well as vernacular landscape. Agriculture represents the broadest human landscape formed by the interaction between the natural environment and local agricultural production, and hence the ratio of agricultural industry structure changes from region to region
	customs	minority population ratio (%), religious population ratio (%), dialect diversity index	– customs are an indispensable aspect of social life and a critical symbol of human culture (Liao, 2006). Among them, ethnic attributes, religious consciousness, and language traditions are typical representatives, bringing unique and diverse perceptions of vernacular landscapes regionally

old) and minority population ratio is derived from the 2010 National Census (http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm). The data on the ratio of agricultural industry structure is taken from the 2017 China County Statistical Yearbook and statistical yearbooks of provinces, municipalities, and autonomous regions. And the data on religious population ratio comes from the 2012 Chinese Family Panel Studies (CFPS) carried out by the Institute of Social Science Survey. Besides, the dialect diversity index, land use type, and traditional dwelling type are learned from experts' research results (Kang, 2019; Peng & Wang, 2006; Xu et al., 2015). The zoning adopts China's counties and merged municipal districts officially designated in 2010 (not including Taiwan Province) as the research units. Moreover, 1 : 4 million basic Chinese geographic information data is used for spatial administrative boundary vectors.

2.2 Principles of comprehensive zoning for Chinese vernacular landscapes

The zoning principle is the primary basis for selecting zoning indicators, formulating zoning methods, and establishing the zoning system, which is also part of the core issues of zoning (Ren & Bao, 1992). The formulation of reasonable zoning principles for vernacular landscapes is a prerequisite to ensure that the zoning process can objectively and truly reflect its differentiation law. Based on the characteristics and zoning objectives set for Chinese vernacular landscapes, the following five principles are determined.

(1) Combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape: The zoning process considers the spatial similarity of natural constituents of vernacular landscape. The areas with apparent consistency of natural constituents are classified as one type of unit. Simultaneously, we consider areas with similar human constituents of vernacular landscape and classify relatively consistent areas as one type of unit. The two types of various spatial unit layers are then superposed and compared to comprehensively regionalize vernacular landscape based on a combination of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape.

(2) Combination of the principles of synthesis and dominant factors: Synthesis analysis emphasizes the careful consideration of factors affecting the vernacular landscape. According to the concept of vernacular landscape, it is necessary to combine the natural and human factors of vernacular landscape and comprehensively analyse their interrelationship and combination structure to objectively and accurately reflect the spatial differentiation law of vernacular landscape. However, when faced with the discontinuous and fragmented areas during the zoning process, the factors that dominate spatial differentiation can be selected as the zoning basis to determine the spatial division. Such factors often control and reflect the basic appearance and characteristics of vernacular landscape in a particular area and play a dominant role compared with other factors.

(3) Combination of the principles of top-down and bottom-up: The top-down deductive approach is usually used to divide the higher-grade spatial units, while the bottom-up inductive approach is often applied in dividing the lower-grade spatial units (Zheng & Fu, 1999). The former refers to from the whole to the part, dividing higher-grade spatial units into lower-grade spatial units according to the law of spatial differentiation. The latter means from part to the whole, merging the lower-grade spatial units into higher-grade spatial units according to the law of spatial combination. This study combines top-down and bottom-up zoning approaches. The top-down approach is used for the higher-grade spatial unit division to understand and distinguish areas at a macro level, and the bottom-up approach is used for the lower-grade spatial unit division to identify specific zoning boundaries.

(4) Combination of the principles of spatial integrity and continuity: Given that Chinese vernacular landscapes have apparent spatial differentiation and diversity, comprehensive zoning should ensure relatively independent regions of vernacular landscapes while maintaining spatial integrity and continuity. Combined with the spatial scale and division basis of each zoning grade, necessary areas are merged or separated to avoid excessive fragmentation of zoning units. Overall, zoning units of vernacular landscapes at all grades should be complete and continuous throughout the national geographical space, neither omission nor overlap.

(5) Principle of hierarchical zoning: Zoning by step is popular in comprehensive zoning. Depending on the importance of influencing factors of the research object, different grades of zoning basis are determined in sequence to carry out zoning by step. Since the similarities and differences of vernacular landscape types and spaces are always relative at different scales, hierarchical zoning can ensure the scientificity and rationality of the division result. Simultaneously, for ease of application and limited data, the paper adopts a two-grade zoning system to divide the country into several vernacular landscape regions, and then every region breaks down into multiple sub-regions. From regions to sub-regions, the scale of vernacular landscape units ranges from large to small, the richness of vernacular landscapes usually ranges from multiple to single, and the similarities within vernacular landscape units vary from unobvious to obvious.

2.3 Methods of comprehensive zoning for Chinese vernacular landscapes

With the technical support of GIS (Geographic Information System), this paper mainly draws on four analysis methods related to geography.

(1) Geometric mean method: For the vernacular landscape factors with compound indicators, the n-th power method is used to comprehensively consider the impact of each indicator. Then, we evaluate the vernacular landscape factors by grading the obtained vernacular landscape factor indexes.

$$SS_j = \sqrt[n]{\prod_i^n C_i} \quad (1)$$

where: SS_j – the vernacular landscape factor index of the spatial unit; C_i – the grade value of indicator i classified according to the relative size of its attribute value

(2) Overlay analysis method: The overlay analysis refers to a zoning method that overlays and merges multiple feature layers that affect spatial differentiation to generate a new layer containing the analysis of previous feature layers (Liu, 2008). In this research, all factor layers are first loaded into the GIS to unify the spatial scale. Then, depending on the type of factors, quantitative overlap calculation or qualitative overlap judgment is applied to classify the areas.

(3) Spatial clustering method: Spatial clustering is an important part of spatial data mining, which clusters or classifies entities based on their characteristics (Li, Wang & Li, 2006a). This research uses the GIS grouping analysis method to perform spatial clustering analysis on the administrative village density and overlay index of quantified human factors of vernacular landscape in order to divide their values into distinct groups.

(4) Comparative analysis method: The zoning result is usually affected by personal identification reasons. Therefore, vernacular landscape comprehensive zoning should seriously learn from experts' experience. Through careful comparison and synthesis with existing relevant research results such as rural regional system type zoning, appropriate and reasonable manual corrections are made to avoid excessive fragmentation and potential division errors. In this way, the optimization of the zoning scheme can be realized, and it is also conducive to the formation of a joint planning implementation mechanism in the future.

2.4 Evaluation of Chinese vernacular landscapes

The research framework of comprehensive zoning for vernacular landscapes of China is shown in Fig. 2. We use indicator data to evaluate every natural and human factor of vernacular landscape through GIS technology in order to clarify their spatial distribution. There are two evaluation approaches depending on the types of evaluation factors. For quantified factors, we analyse factor's attribute value based on the corresponding indicator attributes. And according to the relative size of attribute value and previous grading evaluation

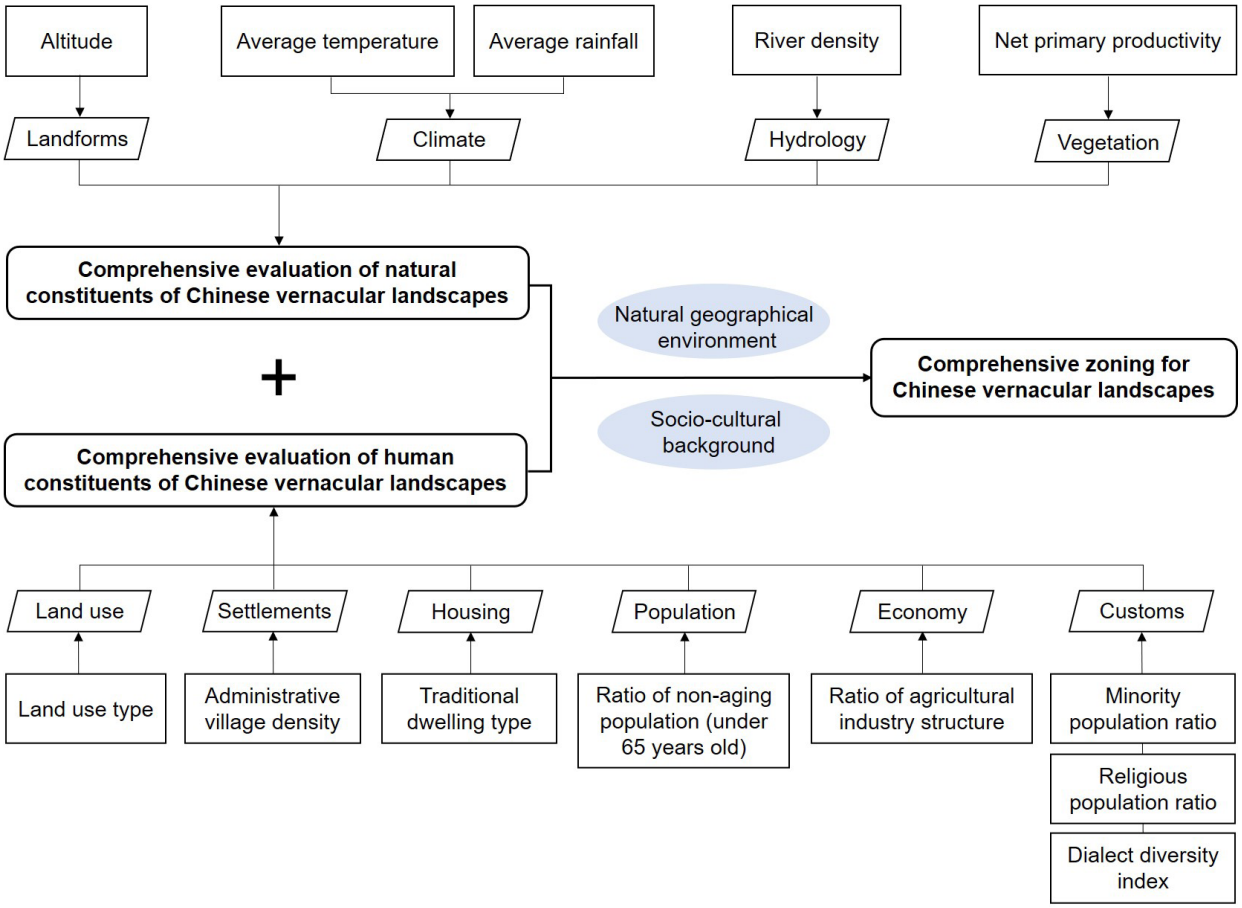
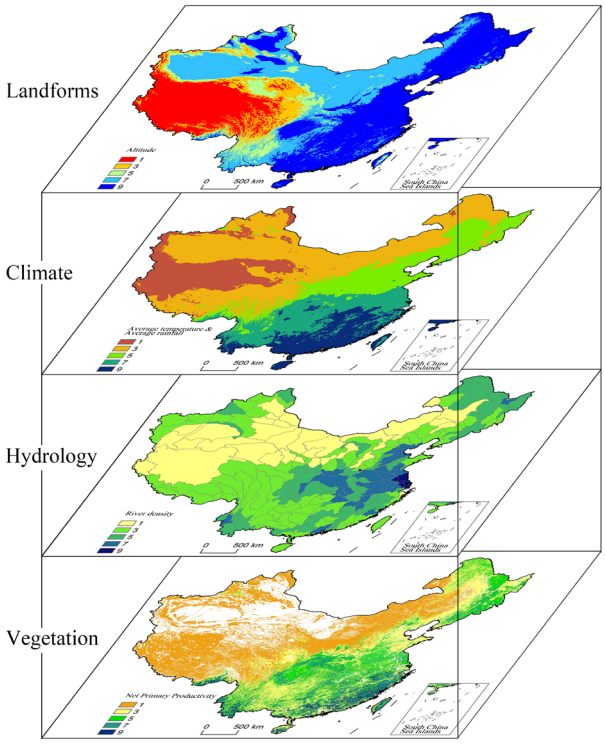


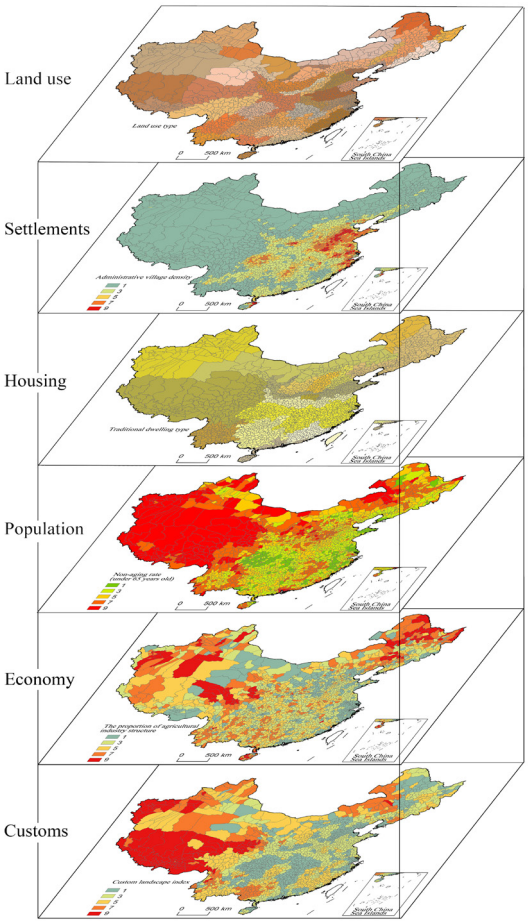
Figure 2 Research framework of comprehensive zoning for vernacular landscapes of China

experience, each factor is classified into five different grades: very small, small, medium, large, very large, and the corresponding assignments are 1, 3, 5, 7, 9. For qualitative factors (land use and housing), combining the characteristics and distribution of the factors, we draw on the experience of relevant zoning studies to clarify various types of regions (Fig. 3a, Fig. 3b).

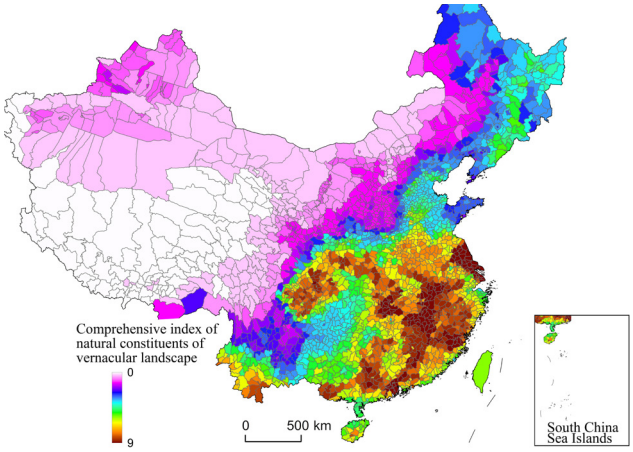
(1) For the natural constituents of vernacular landscape, we comprehensively evaluate it by integrating the grade distribution of landforms, climate, hydrology, and vegetation. With the support of the GIS spatial analysis, the method of the quantitative overlay of equal weight and then averaging is used to calculate the comprehensive index of natural constituents of



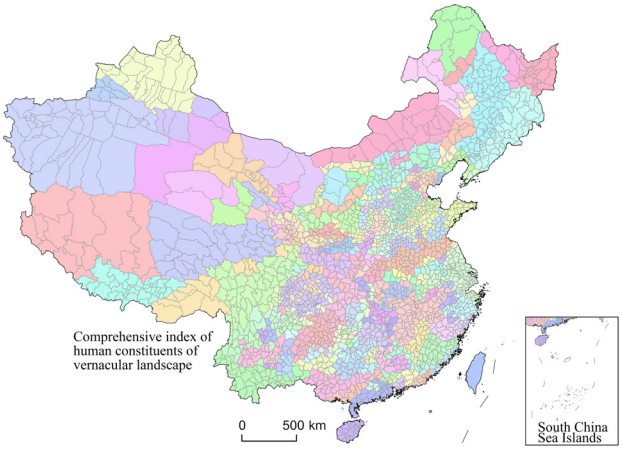
a) Overlay analysis of factors of natural constituents of Chinese vernacular landscape



b) Overlay analysis of factors of human constituents of Chinese vernacular landscape



c) Comprehensive evaluation of natural constituents of Chinese vernacular landscape



d) Comprehensive evaluation of human constituents of Chinese vernacular landscape

Figure 3 Evaluation of comprehensive zoning for vernacular landscapes of China

vernacular landscape in each spatial grid (1,000 × 1,000 m), and then spatially average it to the county-level administrative units. According to the classification of Jenks natural breaks, a comprehensive evaluation map of natural constituents of vernacular landscape is generated (Fig. 3c). It can be seen from the figure that the natural constituents of vernacular landscape are roughly divided by the Hu Huanyong Line, with significant differences between the east and the west. This is consistent with the natural differentiation law between southeast and northwest China and illustrates the rationality and representativeness of the evaluation of natural constituents of the vernacular landscape.

(2) For the human constituents of vernacular landscape, we comprehensively evaluate it by integrating the grade or type distribution of land use, settlements, housing, population, economy, and customs. Since human constituents of vernacular landscape contain quantitative and qualitative indicators, factor evaluation is relatively complicated to quantify uniformly. Therefore, with the support of GIS spatial analysis, the qualitative overlay method is adopted to obtain the regional types of human constituents of vernacular landscape of the county-level administrative units. According to the area of various regional types, combined with data review, map interpretation, and expert judgments, a comprehensive analysis is carried out. The secondary types of areas are classified into the main types of areas based on priority of impact. With reference to certain provincial and municipal administrative boundaries, a comprehensive evaluation map of human constituents of vernacular landscape is generated (Fig. 3d). As can be seen from the figure, there are many types of vernacular landscapes, and most of them are clustered in regions. This is consistent with the characteristic that human constituents of vernacular landscape vary from area to area, and provides a sufficient basis for the detailed zoning of vernacular landscapes.

3 Results

3.1 Strategies for zoning lines in the comprehensive zoning process

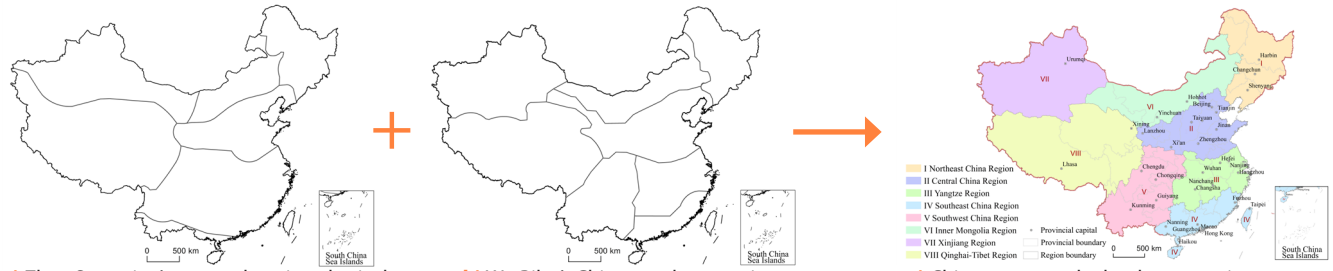
One of the difficulties that have always existed in zoning work is to clarify the boundaries of zoning units (Zhao, Chen & Niu, 1979). This is especially true for the comprehensive zoning of vernacular landscapes. Firstly, because vernacular landscapes are unevenly distributed and transitional, and ambiguous, there is no apparent measurable gradient in space. Secondly, because the spatial boundary is a continuity of points from quantitative change to qualitative change, the boundary is a space where similarities and differences coexist on both sides. Thirdly, the landscape itself mostly depends on intuitive feelings, and border areas are usually more affected by cultural fusion, so the boundaries of vernacular landscapes are blurred.

However, the zoning work requires a clear division without repetition or omission. Therefore, by referencing existing relevant zoning research, such as human geography zoning, rural regional system types, traditional settlement zoning, etc., the basic boundaries of vernacular landscape regions are determined according to the major characteristics and general scope identification of vernacular landscapes. Also, since the division of administrative units is based on various natural geographical environments and socio-cultural backgrounds, it is consistent with the division of vernacular landscape regions. Therefore, this zoning tries to maintain the integrity of provincial and municipal administrative units, which can be of great significance to regional development and management.

3.2 Generating Chinese vernacular landscape regions

First-grade zoning of vernacular landscapes, the division of vernacular landscape regions, is based on the natural geographical environment and socio-cultural background (Western Australian Planning Commission, 2016). It is an effective way to reasonably absorb relevant research results in the study. Hence, the natural geographical environment mainly refers to the 7 natural zones of Zhao Songqiao's comprehensive physical zoning (Zhao, 1983) (Fig. 4a), which are primarily divided according to the combination of temperature and moisture conditions. Each natural zone has consistent climate characteristics, and vegetation, soil, and other landscapes also show some commonalities. The socio-cultural location mainly refers to 8 cultural zones of Wu Bihu's Chinese cultural zoning (Wu, 1996) (Fig. 4b), which are primarily divided based on three significant aspects related to the formation of Chinese cultural zones, including geographic environment, historical development, and relative location, and secondly combined with public fuzzy sensing and recognition of cultural zones. Therefore, according to the general differentiation trend of vernacular landscapes dominated by the natural geographical environment and the socio-cultural background, the country is divided into 8 vernacular landscape regions from top to down using the overlay method of qualitative analysis (the detailed boundary of vernacular landscape regions is clearly defined in conjunction with vernacular landscape sub-regions) (Fig. 4c).

We group and summarize vernacular landscape regions according to 3 natural zones – the eastern zone,



a) Zhao Songqiao's comprehensive physical zoning (Zhao, 1983)

b) Wu Bihu's Chinese culture zoning (Wu, 1996)

c) Chinese vernacular landscape regions

Figure 4 First-grade zoning process of Chinese vernacular landscapes

the north-western zone, and the Qinghai-Tibet zone of Zhao Songqiao's comprehensive physical zoning (Zhao, 1983). The boundary between the eastern zone and the north-western zone is roughly the same as the Greater Khingan Range and the Great Wall of the Ming Dynasty; the boundary between the north-western zone and the Qinghai-Tibet zone is Kunlun Mountain-Altun Mountain-Qilian Mountain, which is also the administrative boundary between Tibet Autonomous Region and Qinghai Province; and the boundary between the eastern zone and Qinghai-Tibet zone is the eastern edge of the Qinghai-Tibet Plateau. Among them, the boundary between the east (the eastern zone) and the west (the north-western zone and the Qinghai-Tibet zone) is a critical geographic boundary across China, which roughly coincides with the 400 mm precipitation line, physical geographic zone boundary, Hu Huanyong line, agroclimatic zone boundary, and population and economic zone boundary.

(1) In the eastern zone, five vernacular landscape regions are divided according to geographical zones and cultural zones, namely Northeast China Region (I), Central China Region (II), Yangtze Region (III), Southeast China Region (IV), and Southwest China Region (V). Among them, Central China Region (II) is bounded by the border of the warm temperate zone and middle temperate zone (near the Ming Great Wall) in the north, next to Northeast China Region (I); it is bounded by the Qinling-Huaihe line in the south, adjacent to Yangtze Region (III) and Southeast China Region (IV). Qinling-Huaihe line is a crucial geographic boundary across China, reflecting the comprehensive differentiation of nature and culture between China's north and south. Southeast China Region (IV) and Yangtze Region (III) are roughly bounded by the boundaries of Guangxi and Fujian administrative units and Nanling belt. And Southeast China Region (IV) contains southern parts of Jiangxi province and a small part of Hunan province. The east boundary of Southwest China Region (V) roughly extends from north to south along the administrative boundaries of Hunan province. And southwest China Region (V) also includes west of Hubei province and northwest of Guangxi province.

(2) In the north-western zone, according to the differences in vegetation, landforms, and ethnic-cultural characteristics, two vernacular landscape regions are divided, taking the boundaries of Xinjiang and Gansu administrative units, namely Inner Mongolia Region (VI) and Xinjiang Region (VII).

(3) In the Qinghai-Tibet zone, according to the special plateau conditions and religious, cultural background, it should be an independent and complete vernacular landscape region, namely Qinghai-Tibet Region (VIII).

3.3 Generating Chinese vernacular landscape sub-regions

Second-grade zoning of vernacular landscapes, the division of vernacular landscape sub-regions, comprehensively considers 10 major vernacular landscape factors, landforms, climate, hydrology, vegetation, land use, settlements, housing, population, economy, and customs. It is mainly based on a combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape to superimpose the comprehensive evaluation of natural constituents of vernacular landscape (Fig. 5a) with the comprehensive evaluation of human constituents of vernacular landscape (Fig. 5b). In addition to the first-grade zoning of vernacular landscapes, the zonings of human geography (Fig. 5c) (Fang et al., 2017), rural regional system types (Fig. 5d) (Liu, Zhou & Li, 2019b), and traditional settlements (Fig. 5e) (Liu et al., 2010) are also used as auxiliary references. Simultaneously, combined with certain provincial and municipal administrative boundaries, 56 vernacular landscape sub-regions are finally divided through complete analysis and comparison (Fig. 6, Table 2).

The methodology used in the zoning process and the definition of vernacular landscape regions in China follows

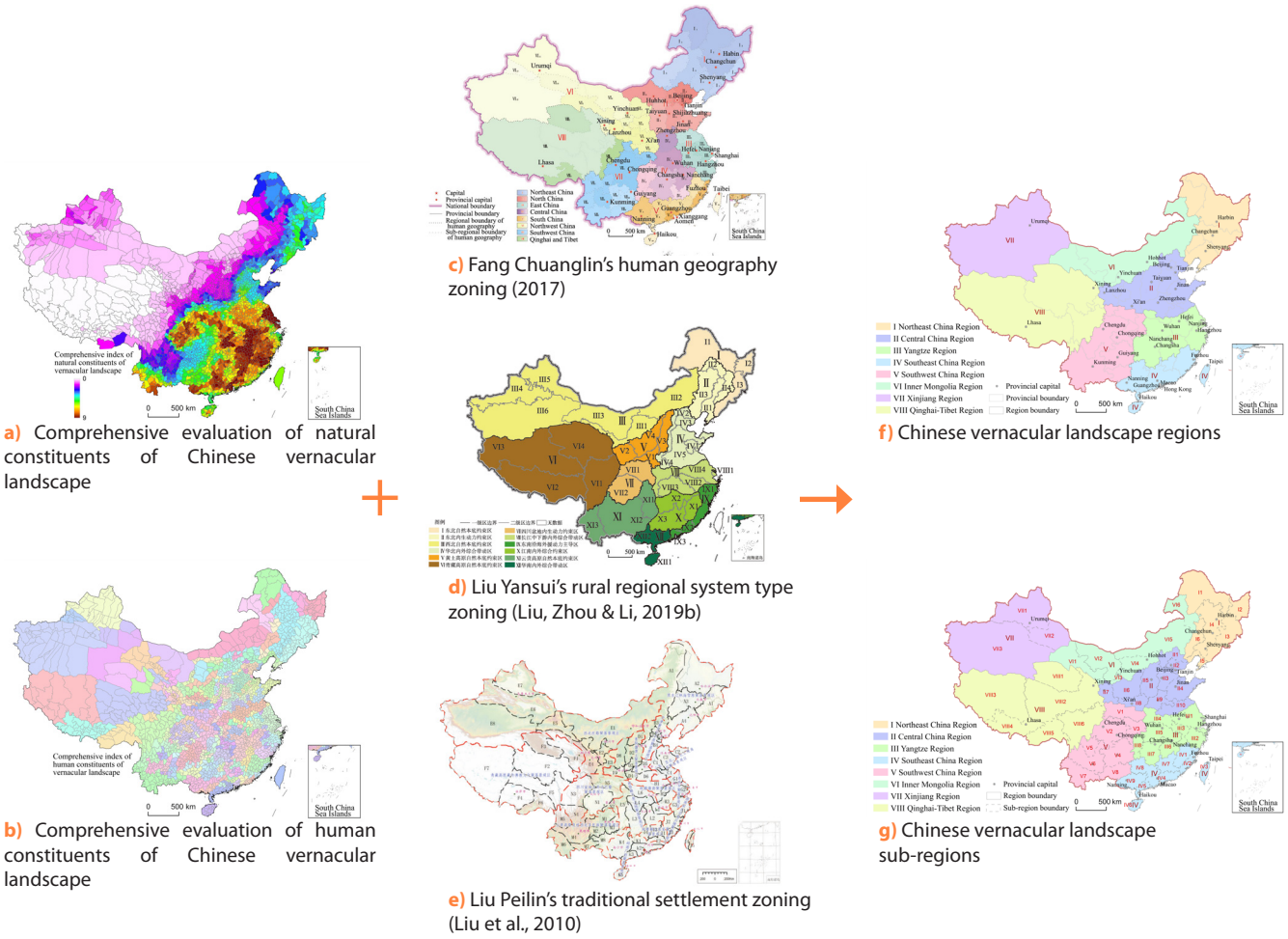


Figure 5 Second-grade zoning process of Chinese vernacular landscapes



Figure 6 Comprehensive zoning scheme for vernacular landscapes of China

the methods and scenarios used at international level. Some examples, case studies and strategies from different European countries (UK, North-Europe, the Mediterranean) and from Middle East shows that the general structure and basic idea in the reservation of vernacular landscapes are everywhere a common basis. The differences are mainly generated by the local natural and cultural conditions and dimensions (Birnbaum, 1994; Saleh, 1998; Palmer & Thérond, 2008; Kingston, 2009; Mitchell, Rössler & Tricaud, 2009; Bourgeau & Vivas, 2018; Altaba Tena & García-Esparza, 2018).

Table 2 Chinese vernacular landscape regions and sub-regions

Coding and naming of vernacular landscape regions	Coding and naming of vernacular landscape sub-regions	Number of sub-regions
Northeast China Region (I)	Greater and Lesser Khingan Range Sub-region (I1), Sanjiang Plain Sub-region (I2), Changbai Mountain Sub-region (I3), Songnen Plain Sub-region (I4), Southern Liaoning Sub-region (I5), West Liao River Basin Sub-region (I6)	6
Central China Region (II)	Northern Hebei Sub-region (II1), Beijing-Tianjin-Tangshan Sub-region (II2), Southern Hebei Sub-region (II3), Shandong Sub-region (II4), Shanxi Loess Plateau Sub-region (II5), Shaanxi-Gansu Loess Plateau Sub-region (II6), Central Gansu Sub-region (II7), Guanzhong Plain Sub-region (II8), Northern Henan Sub-region (II9), Huanghuai Plain Sub-region (II10)	10
Yangtze Region (III)	Lower Yangtze Plain Sub-region (III1), Southern Zhejiang Sub-region (III2), Southern Anhui and Northeastern Jiangxi Sub-region (III3), Hubei-Henan Mountain Sub-region (III4), Hubei-Hunan-Jiangxi Sub-region (III5), Central Jiangxi Sub-region (III6), Central and Southern Hunan Sub-region (III7), Western Hunan Sub-region (III8)	8
Southeast China Region (IV)	Mount Wuyi Sub-region (IV1), Fujian Shore Sub-region (IV2), Taiwan Island Sub-region (IV3), Pearl River Delta Sub-region (IV4), Southwest Guangdong Sub-region (IV5), Hainan Island Sub-region (IV6), Guangdong-Jiangxi-Hunan Hakka Sub-region (IV7), Nanling Sub-region (IV8), Beibu Gulf Sub-region (IV9)	9
Southwest China Region (V)	Qinba Mountain Sub-region (V1), Bashu Basin Sub-region (V2), Western Hubei and Eastern Chongqing Mountain Sub-region (V3), Guizhou Plateau Sub-region (V4), Southwest Sichuan Sub-region (V5), Yunnan Plateau Sub-region (V6), Southwest Yunnan Sub-region (V7), Southeast Yunnan and Northwest Guangxi (V8)	8
Inner Mongolia Region (VI)	Hexi Corridor Sub-region (VI1), Alxa Plateau Sub-region (VI2), Ningxia Plain Sub-region (VI3), Ordos Plateau Sub-region (VI4), Inner Mongolia Northern Plateau Sub-region (VI5), Inner Mongolia Eastern Prairie Sub-region (VI6)	6
Xinjiang Region (VII)	Northern Xinjiang Sub-region (VII1), Tuha Basin Sub-region (VII2), Southern Xinjiang Sub-region (VII3)	3
Qinghai-Tibet Region (VIII)	Hercynian Basin Sub-region (VIII1), Qinghai Plateau Sub-region (VIII2), Western Tibet Sub-region (VIII3), Southwest Tibet Sub-region (VIII4), Southern Tibet Sub-region (VIII5), Western Sichuan Sub-region (VIII6)	6

4 Conclusions

To clarify and distinguish the distribution law and spatial differences of vernacular landscapes, we divide the country into two grades of vernacular landscape spatial units: 8 vernacular landscape regions and 56 vernacular landscape sub-regions. The units are relatively independent and interconnected, and each unit can highlight the typical characteristics of the vernacular landscape in a specific area. Three critical outcomes are obtained in this study, which have both theoretical and practical implications.

1. It argues that vernacular landscape refers to an inseparable complex formed by the interaction between natural constituents and human constituents of vernacular landscape. In this study, while comprehensively considering the similarities and differences of both natural constituents and human constituents of vernacular landscape in different areas, the dominant role of the natural geographical environment and socio-cultural background in influencing the formation of various vernacular landscapes is highlighted, which conforms to the essence of the vernacular landscape.
2. It proposes an indicator system for vernacular landscape comprehensive zoning, which contains the factors of both tangible and intangible vernacular landscapes. We choose two levels of characterizing factors from both natural constituents of vernacular landscape and human constituents of vernacular landscape. Then the indicators greatly reflecting the characteristics of each factor can be determined separately.
3. It provides an approach that integrates quantitative and qualitative analysis with the support of a set of particular principles to evaluate vernacular landscapes. The comprehensive zoning scheme was finally obtained based on indicator evaluation, essential zoning basis, overlay analysis, and comparative analysis methods.

This study reveals a systematic regionalization based on the overall spatial differentiation law of natural constituents and human constituents of vernacular

landscape, which avoids using single and typical rural landscape cases to summarize the entire vernacular landscapes throughout the region. Also, with reference to worldwide experience, the zoning procedure can be seen as a useful tool for formulating corresponding development and planning strategies (Xie, Li & He, 2020; Silva & Acheampong, 2015). And as the focus of landscape research, protected landscapes can be studied deeply on our basis to resolve management conflicts (Hasti et al., 2016; Havrylenko, Shyshchenko & Tsyhanok, 2020). However, due to the limitations of existing data and technical methods, it has not yet been possible to realize dynamic vernacular landscape comprehensive zoning. It is necessary to further improve the zoning means to optimize the vernacular landscape zoning scheme in a timely, accurate, and efficient manner.

Acknowledgments

The authors would like to thank the support of the China Scholarship Council and Stipendium Hungaricum Programme.

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