Evaluating historic preservation zoning using a landscape approach

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Abstract: Historic preservation is generally regarded as an important and appropriate way to exhibit the history of the city; however, the designation of preservation zones requires accurate mapping and is subject to restrictions on contemporary and historical cartography. This paper provides an approach to the evaluation of urban landscape assessment on the basis of geographical "big data". Three components (city plans, the patterns of building forms, and urban land use) are included in the framework of the urban landscape. A three-level evaluation model based on t-tests is developed to determine the effectiveness of historic preservation zoning. The results of a case study of 12 Chinese cities show that, first, not all urban landscape indicators are appropriate for preservation zoning evaluation and, secondly, preservation zones have been designated both larger and smaller than is necessary, which may be explained by discontinuities in some protection policies. Developing a method of historic protection for urban landscapes based on big data is a novel approach, and this study provides meaningful insights into applications for urban design and conservation for decision-makers and academics.

Keywords: historic preservation zoning, urban landscape; planning evaluation; China

Funding

This research did not receive any specific grant from funding agencies in the public,

commercial, or not-for-profit sectors.

1. Introduction

In the twenty-first century, historic preservation (we use the US term instead of the English equivalent ‘conservation’) has become a mainstream component of urban planning and is widely regarded as a key driver of revitalization (Mason, 2009; Ryberg-Webster and Kinahan, 2014). This is a major development from the 1960s and 1970s when the US critic Ada Louise Huxtable wrote trenchant critiques of the impacts of development, design, planning and preservation (Huxtable, 1986). Many studies have noted that historic preservation can facilitate community and economic development (Tyler et al., 2018). Nevertheless, recognition of the value of historic preservation is not uniform across countries, professions or cultures (Jokilehto 1999, Glendinning 2013), and China has come late to recognise this. In the early years, in China as elsewhere, the majority of research and practice focused on individual buildings, especially notable structures and monuments (Whitehand and Gu, 2010). Cultural heritage is usually treated as an isolated historical feature but simultaneously an integrated component of the broad urban landscape (Whitehand et al., 2011). Notably, the recognition of change in this field has been slow to develop but has become evident particularly in the past two decades. For example, the UNESCO World Heritage Centre is no longer concerned solely with isolated sites, but has broadened its view to consider the historic preservation of landscape ensembles (Ringbeck, 2018). Moreover, states now typically identify and characterize extensive areas of urban heritage (Bandarin and

Van Oers, 2012).

In adjusting to this evident broadening of perspective into a more comprehensive approach by scholars and planning practitioners, the substantial body of fundamental research on historical urban landscapes has contributed to informing historic preservation policies and actions (Whitehand and Gu, 2010). Three sets of approaches to urban landscapes are most relevant: the Conzenian historico-geographical school of thought (Whitehand, 2001), the Muratorian process typological school (Cataldi, 2003; Maretto, 2013) and the Versailles historical school (Darin, 1998). Although the three perspectives differ in their research methods, they rely heavily on historical maps or survey materials and, indeed, on the urban landscape itself (Oliveira et al., 2015). These materials include the source materials for virtually all urban morphological studies in western, advanced capitalist countries: providing data on developed street structures, parcels, ~~and the~~ block plans and building forms for numerous cross-sections in time, sometimes spanning hundreds of years (Birkhamshaw and Whitehand, 2012). The concepts have been shown to have wide international applicability (for example M.P. Conzen, 2009), and have been applied with some success to the very different socio-political context of China (Whitehand and Gu, 2007; J. Zhang, 2015).

In countries with limited mapping technology, or where resources are strictly controlled for political, military or other reasons, however, these source materials (except for the surviving physical urban fabric itself) are far less readily available, especially for periods before World War II, and occasionally into the more recent past (Whitehand and Gu, 2007; Gu and Zhang, 2014). This limitation hinders the historical precision normally associated with these approaches. The growing number, range and sophistication of relevant studies have not overcome these limitations; therefore, there are often few unambiguous and evidence-based answers to practical and policy questions. An innovative research method for historic preservation that overcomes this limitation would be beneficial both to theory and practice, and a key component of this would be a means of scientifically evaluating historic preservation zoning. Therefore, this study attempts to add to the literature in following significant way.

We develop a quantitative system for urban landscapes based on emerging geographic "big data", which could be used instead of official topographic maps to portray urban landscapes. Thus far, relatively little research in urban morphology has used big data, data mining or related approaches (a rare exception is Gil *et al.*, 2012). Diachronic methods are often limited by missing mapping and record information in comparison to information collected by modern measurement technology. Therefore, geographic "big data" are more applicable to urban analysis, and theory development and testing, in the current environment. In addition, there are two advantages of geographic "big data". On the one hand, no period limitation exists since the onset of big data collection/availability. The rapid development of information and communication technologies (ICTs) has led to the collection and storage of considerable amounts of real-time data (He et al., 2018) which can often be accessed for research purposes. On the other hand, there is no scale limitation. Traditionally-surveyed maps are usually drawn at standardized and fixed scales, which constrains data integration and comparison. To overcome such limitations, this paper introduces an innovative technical system for measuring urban landscapes and historic preservation.

Although big data approaches are more often used for larger-scale problems, their application to historic preservation and urban planning significantly addresses the 'missing data' problem identified above. Moreover, this approach easily assembles the necessary big data. Compared with the complexity of work in the Chinese traditional planning context, big data technology can also greatly facilitate efficiency of analysis. In the following paper, we also elaborate on how the use of crawler technology can minimise the time taken for these tasks.

The paper is structured as follows. Section 2 introduces an analysis framework. The data are described and the methods are presented in Section 3. Then, an empirical case study based on several metropolitan areas in China is given. In the final section, the conclusions are summarized, and policy implications are drawn.

2. Analysis framework

2.1 Review and measurement of the urban landscape

The landscape is a basic concept across many disciplines such as geography, planning, Earth sciences, architecture, and art in Anglophone and non-Anglophone countries (Morin, 2009). Hence, the concept of landscape is often ambiguous or complex (Alonso de Medina *et al*., forthcoming), resulting in multiple and nuanced landscape traditions. Numerous geographical categories are related to the landscape (e.g. regional attributes, scenery, topography, and the environment); different scales need to be included; and consideration of 'the landscape' (certainly in Anglophone contexts) often omits the built landscape – often referred to as 'urban landscape' or 'townscape'. Although the visual physical world is frequently emphasized in terms of its 'ordinary' everyday expression (Meinig, 1979), another approach may be more suitable in many cases. Thus a landscape may be thought of as the appearance of an area, and the particular components of that area are arranged to produce that appearance (Morin, 2009). This perspective can be traced to the influential US geographer Carl Sauer, who adapted German concepts to examine the change from a physical landscape to a cultural landscape (Sauer, 1925). On this basis, urban landscapes are separated from rural landscapes based on their different forms and characteristics; although concepts developed at the urban scale can often be applied to rural settlements even of small scale (compare Sheppard, 1974 and Slater, 1981). But Sauer's approach was entirely non-quantitative, and in the revolution of geographical thinking and techniques of the 1960s his approaches came to be derided as "bumbling amateurism and antiquarianism" (Gould, 1979, p. 140).

The controversy does not stop at the conception of a landscape. Opinions regarding landscape research methodologies widely vary. Two types of methodologies have generally been used in previous studies: one is descriptive and explanatory to develop a historico-geographical theory of city building and form (M.R.G. Conzen, 1960), and the other is reducible and deductive to explore the mechanisms of landscape formation (Wu et al., 2019). Both methods are diachronic. A synchronic measurement method is needed to extend the research scope of the building environment. Therefore, by following the landscape research approach derived from Sauer (1925) and other scholars, including the three 'form complexes' identified by M.R.G. Conzen (1960), a measurement framework has been developed to portray the urban landscape based on three layers: the city plan, the pattern of building forms, and urban land use (Figure 1).

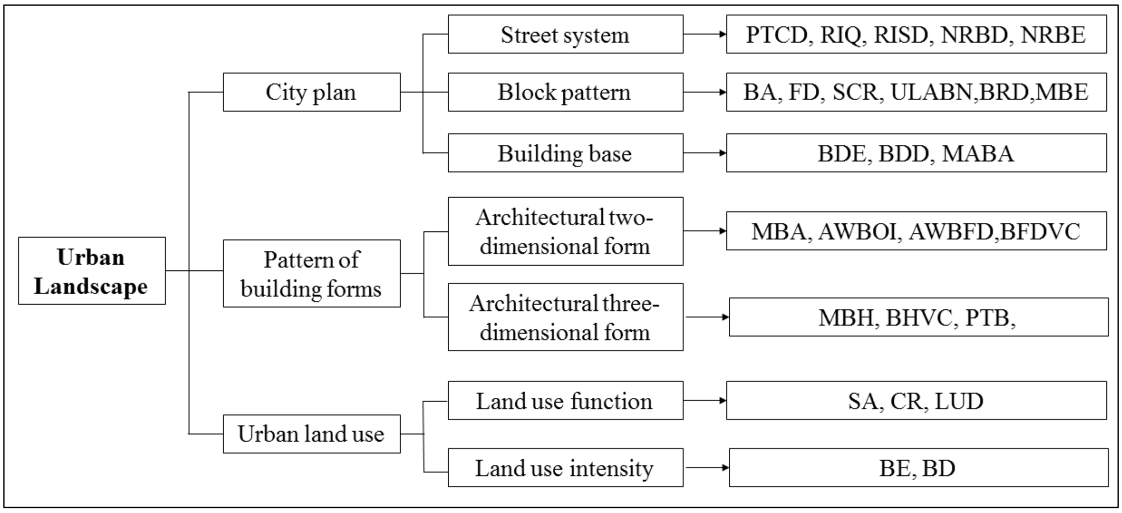


Figure 1 The framework of urban landscape measurement.

The city plan is composed of three sub-sets, the street system, block pattern, and building base, according to the Conzenian school of thought. In the building forms layer, there are two categories: architectural two-dimensional forms and architectural three-dimensional forms. In addition, urban land use is disaggregated into two classes: the land-use function and land-use intensity. Each sub-set includes several measurement variables (Table 1 and 2). The measurement details have been discussed in detail, and their applicability demonstrated, in recent studies (Wu et al., 2019; A. Zhang et al., 2019).

Table 1 The variables of the urban landscape

Variables of the urban landscape	**Abbreviation**
City plan	
Street system	
Public Transportation Convenience	PTC
Number of Road Intersection	RIQ
Road Intersection Separation Distance	RISD
Near-Road Building Density	NRBD
Near-Road Building Expandability	NRBE
Block pattern	
Block Area	BA
Fractal Dimension	FD
Spatial Compactness Ratio	SCR
Adjacent Block Number Per Unit Length	ULABN
Block Relief Degree	BRD
Mean Block Elevation	MBE

Building base	
Eccentricity Degree of the Building Distribution	BDE
Dispersion Degree of the Building Distribution	BDD
Max. Building Area	MABA
Pattern of building forms	
Architectural two-dimensional forms	
Mean Building Area	MBA
Building Area-Weighted Orientation Index	AWBOI
Building Area-Weighted Fractal Dimension	AWBFD
Building Spatial Compact Ratio Variation Coefficient	BSCRVC
Building Area-Weighted Spatial Compactness Ratio	AWBSCR
Architectural three-dimensional forms	
Mean of Building Height	MBH
Building Height Variation Coefficient	BHVC
Proportion of Tower Buildings	PTB
Urban land use	
Land use functions	
Residential Service Ability	SA_RE
Public Service Ability	SA_PU
Commercial Service Ability	SA_CO
Industrial Service Ability	SA_IN
Transportation Service Ability	SA_TR

Green Space Service Ability	SA_GS
Residential Category Ratio	CR_RE
Public Category Ratio	CR _PU
Commercial Category Ratio	CR _CO
Industrial Category Ratio	CR _IN
Transportation Category Ratio	CR _TR
Green Space Category Ratio	CR _GS
Land Use Diversity	LUD
Land use intensity	
Building Expandability	BE
Density of Buildings	BD

Table 2. Quantification system of urban landscape.

Components of urban landscape		**indicators**	**Code**	**Meaning**	**Formula or Explanation**
City plan pattern	street system	Public Transportation Convenience	PTC	The ratio of the number of transportation stops (e.g. bus stops, subway stations and taxi stops) within 500 metres of the block to the block area	$PTCD_{ij} = \frac{k_i^S Subway_{ij}+k_i^B Bus_{ij}+k_i^T Taxi_{ij}}{A_{ij}}$, $k_i^S = \frac{Subway_i \cdot A_{all}}{Subway_{all} \cdot A_i}$, $k_i^B = \frac{Bus_i \cdot A_{all}}{Bus_{all} \cdot A_i}$, $k_i^T = \frac{Taxi_i \cdot A_{all}}{Taxi_{all} \cdot A_i}$ where *i* means city *i* and *j* means block *j*. $Subway_{all}(Bus_{all}\ or\ Taxi_{all})$, $Subway_i(Bus_i\ or\ Taxi_i)$ or $Subway_{ij}(Bus_{ij}\ or\ Taxi_{ij})$ are the total amount of subway stations (bus or taxi stops) in all cities, in city *i*, or standardized quantity within 500 metres of the block *j*, respectively. A_{all}, A_i and A_{ij} represent the total area of the study area in all cities or in city *i* and the area of the block *j*, respectively. k_i^S, k_i^B and k_i^T represent the weighting factors of the accessibility of subways, buses, and taxis, respectively. Characterizing the convenience of residents taking public transportation.

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
	Road Intersection Quantities	*RIQ*	The weighted quantities of road intersections within 500 metres of the block.	$$RIQ_{ij}=\sum_{n=1}^{N}\frac{R_n}{\sum_r^{R_n}\frac{Type_{nr}}{R_n}}$$ where N is the number of road intersections within 500 metres of the block j. R_n is the number of road sections passing the n-th intersection. $Type_{nr}$ is the grade of r-th road section which pass the n-th road intersection. Characterizing the traffic flow.
	Road Intersection Separation Distance	*RISD*	The average distance between all road intersections and their directly connected road intersections within 500 metres of the block.	$$RISD_{ij}=\sum_{n=1}^{N}\frac{R_n\cdot\sum_r^{R_n}\frac{Length_{nr}}{R_n}}{\sum_r^{R_n}\frac{Type_{nr}}{R_n}}$$ where $Length_{nr}$ is the length of r-th road section which passes the n-th road intersection. Characterizing the walkability of the road.
	Near-Road Building Density	*NRBD*	Ratio of the total building footprint area to total area of the near-road district within 15 metres from the boundary of the	$$NRBD_{ij}=\frac{NRBA_{ij}}{NRA_{ij}}$$ where $NRBA_{ij}$ and NRA_{ij} are the total area of the building footprint and the near-road district within 15 metres from the boundary of the block j, respectively.

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
			block.	Characterizing building density in near-road district, and reflecting the total of building frontage width.
	Near-Road Building Expandability	*NRBE*	Ratio of the total building volume to the total area of the near-road district within 15 metres from the boundary of the block	$NRBE_{ij} = \frac{NRBV_{ij}}{NRA_{ij}}$ where $NRBV_{ij}$ is the total building volume within 15 meters from the boundary of the block *j*. Characterizing the space occupancy of buildings in near-road district and reflecting average height of near-road buildings
block pattern	Area	*A*	The area of the block	Characterizing the size of the block
	Fractal Dimension	*FD*	Complexity of the shape of the block	$FD_{ij} = \frac{2ln(\frac{P_{ij}}{4})}{ln\,A_{ij}}$ where P_{ij} is the perimeter of the block *j*. When *FD*=1, the block is square. The higher value of *FD* means that the shape is more complicated.
	Spatial Compact	*SCR*	Compactness of the shape of the block	$SCR_{ij} = \frac{2\sqrt{\pi A_{ij}}}{P_{ij}}$

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
	Ratio			When *SCR*=1, the block is circle. The higher value of *SCR* means that the shape is more compact.
	Block Relief Degree	*BRD*	The average slope within the block	Characterizing flatness-level on the surface of the block. The higher the value, the larger the surface slopes or undulates.
	Adjacent Block Number Per Unit Length	*ULABN*	Ratio of the number of adjacent blocks of the target block to its perimeter	$$ULABN_{ij} = \frac{Near_{ij}}{P_{ij}}$$ where $Near_{ij}$ is the number of adjacent blocks of the block *j* within 100 metres from the boundary. The lower the value, the more independent the block distribution.
	Mean of Block Elevation	*MBE*	The average elevation within the block	Characterizing the terrain of the block.
building arrangement	Eccentricity Degree of Building	*BDE*	Average distance between each building and the centre of the block	$$BDE_{ij} = \sqrt{\frac{\pi}{A_{ij}}} \cdot \frac{D_{ij}}{\cdot B_{ij}} = \sqrt{\frac{\pi}{A_{ij}}} \cdot \frac{\sum_{b=1}^{B_{ij}} D_b}{\cdot B_{ij}}$$ where D_{ij} is the sum of the distances between each building and the geometric

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
	Distribution			centre. D_b is the distance between building *b* and the geometric centre. B_{ij} is the total number of buildings of the block *j*. In order to establish comparable standards for *BDE* in blocks of different areas, standardization is carried out using the circle of the same area as the block. When BDE is large enough, it means that the distribution of buildings is enclosing (ie perimeter blocks). On the contrary, if the value is very small, the buildings are concentrated in the geometric centre of the block.
	Dispersion Degree of Building Distribution	*BDD*	Variation coefficient of the distances between each building and the centre of the block	$BDD_{ij} = \frac{\sqrt{\frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}}(D_b - \frac{D_{ij}}{B_{ij}})^2}}{\frac{D_{ij}}{B_{ij}}}$ If the *BDD* is low, the buildings distribute close to the block or like circle layers.
	Max of Building Area	*MAX_BA*	The maximum building footprints area of all buildings in the block	Characterizing the size of the core building area.

Components of urban landscape		indicators	Code	Meaning	Formula or Explanation
Building forms pattern	building's two-dimensional form	Mean of Building Area	MBA	Mean of all buildings' footprint area in the block	$MBA_{ij} = \frac{BA_{ij}}{B_{ij}} = \frac{\sum_{b=1}^{B_{ij}} BA_b}{B_{ij}}$ where BA_{ij} is the sum of the buildings' footprint area. BA_b is the footprint area of building *b*. Characterizing the size of the buildings in the block.
		Building Area-Weighted Orientation Index	$AWBOI$	Weighted mean of all building orientations in the block	$AWBOI_{ij} = \sum_{b=1}^{B_{ij}} \frac{BA_b \cdot \sum_{b=1}^{B_{ij}} Angle_b}{BA_{ij}} = \sum_{b=1}^{B_{ij}} \frac{BA_b \cdot \sum_{b=1}^{B_{ij}} Angle_b}{\sum_{b=1}^{B_{ij}} BA_b}$, $Angle_{ij} = \begin{cases} \left\lvert tan^{-1} \frac{X_{To} - X_{From}}{Y_{To} - Y_{From}} \right\rvert, Y_{To} \neq Y_{From} \\ \frac{\pi}{2}, Y_{To} = Y_{From} \end{cases}$ where $Angle_{ij}$ is the orientation of building *b*. The starting point coordinates and the end point coordinates of the longest side of the footprint of building *b* are (X_{From}, Y_{From}) and (X_{To}, Y_{To}), respectively. This paper defines the building orientation as the angle between the longest side of the building footprint and the true north. For northern hemisphere cities, the higher the value, the more the light can be received by the building, and for southern hemisphere cities, and it is

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
				opposite.
	Building Area-Weighted Fractal Dimension	$AWBFD$	Weighted mean of the Fractal Dimension of all building footprints in the block	$$AWBFD_{ij}=\sum_{b=1}^{B_{ij}}\frac{BA_b\cdot\sum_{b=1}^{B_{ij}}BFD_b}{BA_{ij}}$$ where BFD_{ij} is the Fractal Dimension of building *b*. Characterizing the mean complexity of the shape of building footprints in the block.
	Building Area-Weighted Spatial Compact Ratio	$AWBSCR$	Weighted mean of the Spatial Compact Ratio of all building footprints in the block	$$AWBSCR_{ij}=\sum_{b=1}^{B_{ij}}\frac{BA_b\cdot\sum_{b=1}^{B_{ij}}BSCR_b}{BA_{ij}}$$ where $BSCR_{ij}$ is the Spatial Compact Ratio building *b*. Characterizing the mean compactness of the shape of building footprints in the block
	Building Fractal	$BFDVC$	Variation coefficient of Fractal Dimension of all building	$$BFDVC_{ij}=\frac{\sqrt{\frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}}(BFD_b-MBFD_{ij})^2}}{MBFD_{ij}},\ MBFD_{ij}=\frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}}BFD_b$$

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
	Dimension Variation Coefficient		footprints in the block	where $MBFD_{ij}$ is the average of the Fractal Dimension of all building footprints in block j. Characterizing the diversity of architectural forms' complexity in blocks
	Building Spatial Compact Ratio Variation Coefficient	$BSCRVC$	Variation coefficient of Spatial Compact Ratio of all building footprints in the block	$$BSCRVC_{ij} = \frac{\sqrt{\frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}}(BSCR_b - MBSCR_{ij})^2}}{MBSCR_{ij}}$$ $$MBSCR_{ij} = \frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}} BSCR_b$$ where $MBSCR_{ij}$ is the average of the Spatial Compact Ratio of all building footprints in block j. Characterizing the diversity of architectural forms' compactness in blocks
building's three-dimensional	Mean of Building Height	MBH	Mean of all buildings' height in the block	$$MBH_{ij} = \frac{BH_{ij}}{B_{ij}} = \frac{\sum_{b=1}^{B_{ij}} BH_b}{B_{ij}}$$ where BH_{ij} is the sum of all buildings' height in block j, BH_b is the height of building b. The larger the value is, the higher the average building height is, and the

Components of urban landscape		indicators	Code	Meaning	Formula or Explanation
	form				more obvious the three-dimensional trend of the architectural landscape.
		Building Height Variation Coefficient	*BHVC*	Variation coefficient of Building Height in the block	$BHVC_{ij}=\frac{\sqrt{\frac{1}{B_{ij}}\sum_{b=1}^{B_{ij}}(BH_b-MBH_{ij})^2}}{MBH_{ij}}$ Characterizing the diversity of the buildings' height in the block, and reflecting the space hierarchical level of architectural landscape.
		Proportion of Tower Building	*PTB*	Proportion of buildings with high space usage in blocks.	$PTB_{ij}=\frac{TB_{ij}}{B_{ij}}$ where TB_{ij} is the number of tower buildings of the block *j*. This paper defines tower buildings as those having more than 10 floors and whose BSCR is higher than 0.8.
Land use pattern	land use function	Service Ability	*SA*	The ability of facilities in the block to provide a variety of functional services.	$SA_{ij}^m=\frac{POI_{ij}^m}{A_{ij}}$ where SA_{ij}^m is the service ability of function *m* provided by the block *j*. POI_{ij}^m is the standardized quantity of *m*-type POI. The number of *m*-type POI is standardized

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
				by the total number of *m*-type POI in the whole country.
	Category Ratio	CR	The proportion of specific types of functional services in the block	$$CR_{ij}^{m}=\frac{POI_{ij}^{m}}{POI_{ij}^{all}}=\frac{POI_{ij}^{m}}{\sum_{m=1}^{M}POI_{ij}^{m}}$$ where CR_{ij}^{m} is the proportion of *m*-type functional services and POI_{ij}^{all} is the sum of various POI standardized quantities in the block *j* . Reflecting the importance of each types of functional services in the block.
	Land Use Diversity	LUD	The diversity of land utilize in the block	$$LUD_{ij}=-\sum_{m=1}^{M}CR_{ij}^{m}\cdot lnCR_{ij}^{m}$$ where *M* is the total number of categories of POI in the block *j* demonstrating the abundance of service types provided by the facilities in the block.
land use intensity	Building Expandability	BE	The ratio of the total volume of the buildings in the block to the total area of the block.	$$BE_{ij}=\frac{\sum_{b=1}^{B_{ij}}BV_{b}}{A_{ij}}$$ where BV_{b} is the volume of the building *b*.
	Building Density	BD	The ratio of the total area of the building footprints in the block	$$BD_{ij}=\frac{BA_{ij}}{A_{ij}}$$

Components of urban landscape	indicators	Code	Meaning	Formula or Explanation
			to the total area of the block.	

Note: variables appearing multiple times have the same meaning as their first occurrence.

Urban landscapes represent the investment of past labour and capital, and dominant values and fashions, creating a composite morphological framework that often both constrains future development and offers considerable resistance, or inertia, to change. In addition, blocks are the basic unit of detailed plans, and they normally directly shape urban landscape design (cf Panerai et al., 2004). Therefore, the block has been selected as the basic measurement unit. Examples of the urban landscape measurement results are shown in Figure 2.

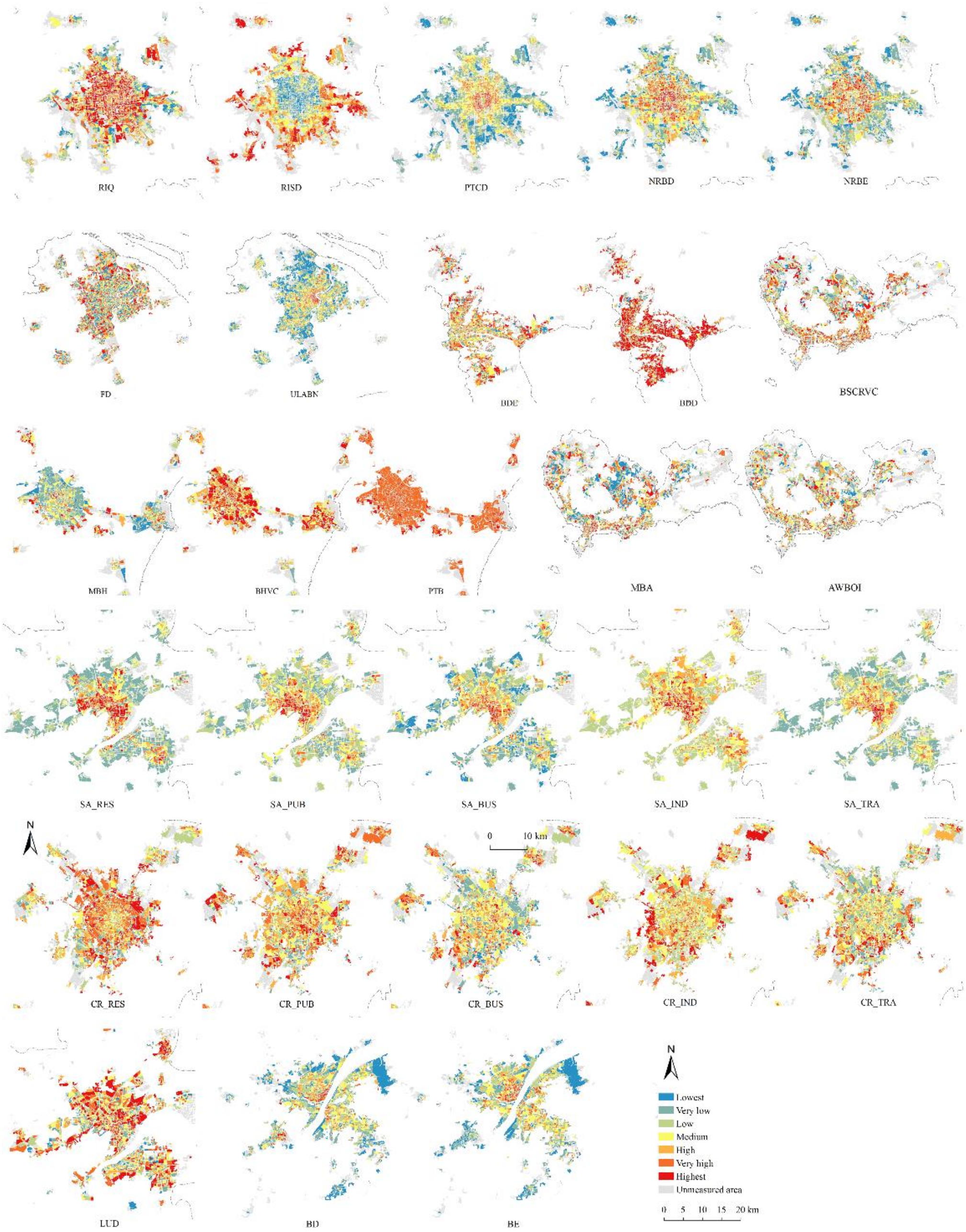


Figure 2 The mapping of the urban landscape variables in sample cities

2.2 Evaluation of historic preservation zoning

As a public policy, the assessment of plans (e.g. urban development plans and land use plans) is often based on whether the expected processes have been implemented and relevant objectives achieved over the set period (Berke et al., 2006). Opinions on historical plans are often formed after decades of hindsight. However, it is more difficult to evaluate contemporary plans, as future conditions are very likely to change, leading to different evaluation standards (Berke et al., 1997). Therefore, despite the growing number of evaluation studies conducted by researchers and consultants, there is still a gap in knowledge regarding evaluations of plan quality (Berke and Godschalk, 2009) due to the lack of accepted plan quality standards.

Despite the complexity and future-oriented nature of plan evaluation, plans can still be evaluated according to contemporary standards of good practice (Knaap et al., 2001). There have been some attempts to build evaluation frameworks to determine what constitutes a good plan. Baer (1997) reviewed the literature on plan evaluation, summarized the published criteria and developed a vocabulary for plan evaluation. Other researchers focused more on the goals, policies and results of planning (Kaiser et al., 1995; Kaiser and Davies, 1999). Hopkins (2001) suggested that plans should be externally validated to meet the goals of local situations. The plan evaluation approach proposed by Berke et al. (2006) has been widely applied. They suggested that two conceptual dimensions be included in plan quality evaluation based on the internal and external plan quality. More recently, Grădinaru et al. (2017) use an evaluation framework based on spatially explicit information, indicators capable of capturing landscape changes in both time and space, and a multi-criteria analysis. They also emphasise that the gap between objectives and outcomes can be attributed to differences in national spatial planning approaches.

However, a research gap exists in planning evaluation, as previous studies have focused more on written plan documentation rather than data such as zoning maps. It is easy to evaluate actual – or even proposed – developments but difficult to assess the effect of spatial regulations, such as historic preservation zoning. Much has been done by inference, for example charting the numbers and types of development proposals within zoned areas (Larkham, 1992). Even as processes have become more digital, few planning authorities have the resources to monitor urban landscape change and hence policy effectiveness. Hence an evaluation framework has been developed to analyse the rationality of historic preservation zoning based on the urban landscape dataset discussed above (Figure 3). The effectiveness of zoning can be explored by examining the amount of measured change within, adjacent to, and around zoned areas. Using the t-test as an analysis approach, the evaluation can be divided into three parts. First, differences among blocks inside and outside historic preservation zones are compared. The historic preservation zoning is considered effective if the t-test results are significant. Secondly, the blocks inside historic preservation zones and those located at the outer edges of zones are compared. The historical preservation zoning is considered to be moderately effective if the t-test results are insignificant, or if the zoning is relatively large. Finally, the blocks inside historic preservation zones and those located outside but adjacent to historical preservation zones are considered in t-tests. Similarly, the historic preservation zoning is considered to be effective if the results are significant, and *vice versa*.

According to the routine t-test procedure, the normal distribution of each urban landscape measurement index is first checked. However, due to the apparent randomness and non-reproducibility of urban development and construction, even if the measurement index is normal, it cannot meet the prior conditions of the t-test. In addition, we exclude the outliers of each measure across a city. The t-tests were completed by testing the variance in the homogeneity of the samples.

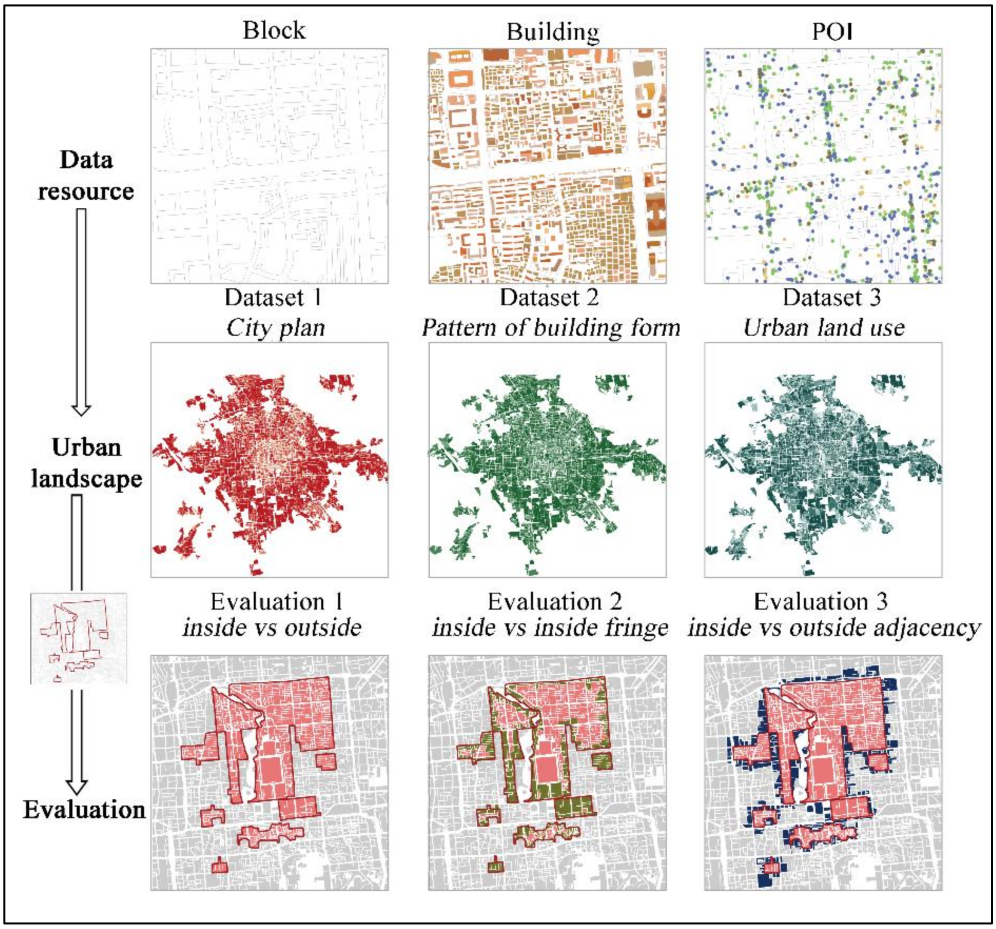


Figure 3 Analysis framework

3. Empirical cases

3.1 Study area

China, as an ancient civilization with a wealth of urban heritage (UNESCO–ICOMOS, 2008), has been selected as the country for empirical study. Historic preservation in China in recent decades has encountered a range of challenges in the context of rapid economic growth and social progress (Bell, 2014; Wang, 2017). In the new century, historic preservation (of cities and wider culture) in China has experienced significant professional progress in addition to innovative practices and theoretical exploration (Jin and Zhao, 2003; Zhu and Goethert, 2010).

The Law of the People's Republic of China on the Protection of Cultural Relics was established in 1982 and is still the most important legislation relating to historic preservation in China. Under the provisions of this law, a national list of historical cultural cities was introduced, also in 1982 (S. Zhang, 2013). Subsequently, area-based preservation was established in 1986, represented by historical cultural conservation areas (Whitehand and Gu, 2007). The government specified that urban heritage should be designated for historic preservation zoning and that their boundaries and associated construction control areas should be mapped at a given scale based on a detailed development control plan, including land use, building height, and FAR (Floor Area Ratio) information.

Based on these national policies, a group of Chinese cities, including Beijing and Foshan, adopted historic preservation zoning between 1999 and 2004 (Wu and Wang, 2007). However, this period of planning and plan implementation suffered from problematic technical bottlenecks. The boundaries of historic preservation zoned areas were not clearly articulated (Chen and Thwaites, 2018) due to uncertain criteria and inconsistent delineation standards. These deep-seated problems reduced the credibility and implementation efficiency of historic preservation zoning (Zhang, 2013). Although urban conservation theories and methods developed in Europe were introduced in China after the mid-1980s, in general, the theoretical development and implementation of such plans have been slow to gain traction in Chinese history and culture-specific applications (Gu and Zhang, 2014.).

This research has used twelve Chinese city centres as case studies (Beijing, Shanghai, Tianjin, Guangzhou, Hangzhou, Wuhan, Chengdu, Nanjing, Qingdao, Shenyang, Changsha, and Suzhou). These cities have long histories and have been identified nationally as historical cultural cities. Historic preservation zoning plans (Figure 4) have been established for these cities over the past two decades.

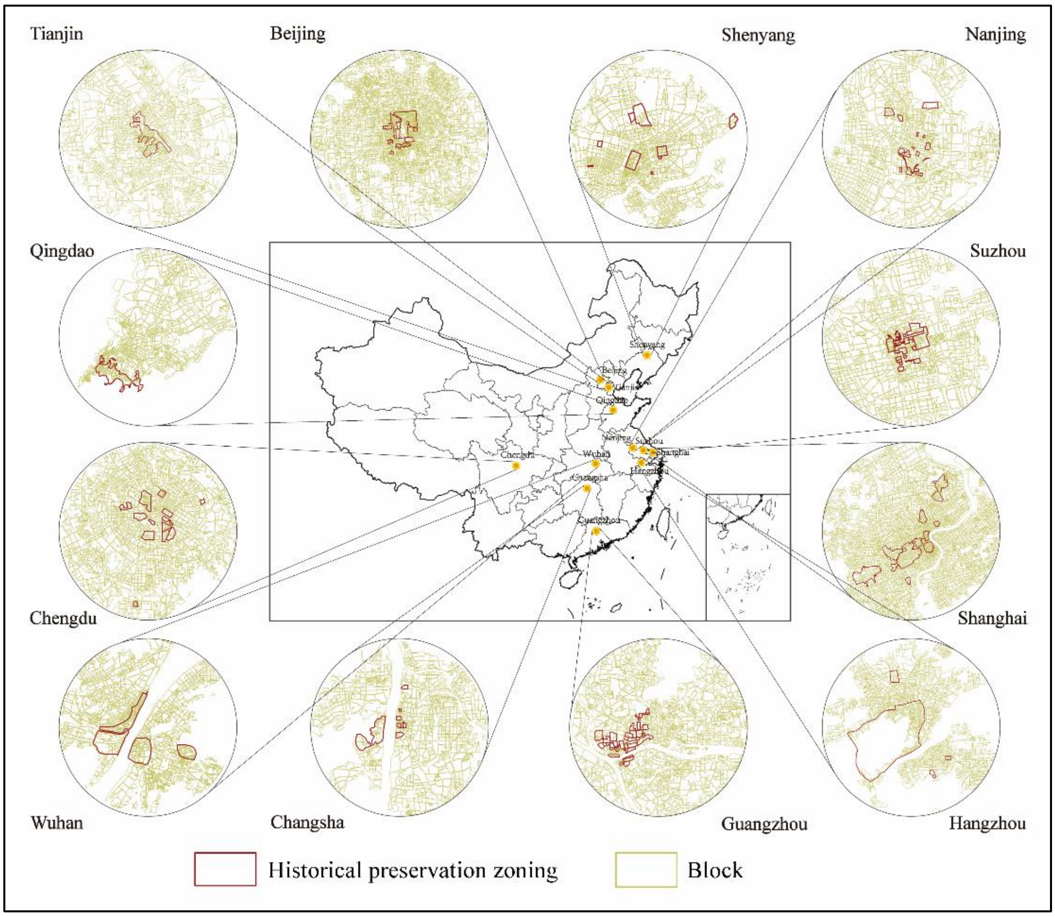


Figure 4 Study areas

3.2 Data collection

With the development of ICT, geographical big data are now widely used in academic research (Wu et al., 2018). Data, such as point of interest (POI), location check-in, mapping, and other data supported by ICT , are generated with location information. Geographic big data is generated at a certain location and changes over time for various elements of the geographical world. This study draws data from four primary sources.

Building and street data. Building and street data are the most important for quantifying urban landscapes. The architectural vector database of Gaode Maps contains data on the architecture location, base area, and number of floors. The functions of Gaode Maps are similar to those of Google Maps, and this map database is commonly used in mainland China. It should be noted that this database only covers the central urban areas of approximately 70 major cities in China. Therefore, data are not available for small cities in remote areas or for the suburbs of large cities.

Building data can be obtained ethically and at no financial cost through crawler technology. It only takes 20 hours to crawl the data of more than 70 major cities in China. In addition, the building data will be updated from time to time.

The street data, which were used to establish block units, were also from Gaode Maps. Street data can be obtained at no cost on application to Gaode Maps, and immediately after submitting the application.

The building and street data were obtained in 2017 and have been used by scholars to assess urban form characteristics (S. Zhang et al., 2019). The differences among urban landscapes over time are evidence that the urban landscape is historically stratified based on the differential survival of features of past periods. This stratification results in daedal characteristics for various parts of an urban area according to the period in which it was created or adapted (Whitehand, 2009). Therefore, urban landscape units have given rise to spatial groupings of form ensembles that reflect the “form period” of the blocks as they represent the static investment of past labour and capital, and offer great resistance to change. The blocks were formed by the five-level enclosure roads whose pattern has a morphological influence upon later development. An antecedent landscape units can exert a morphological influence on subsequent more or less conformable plan development.

POI data. The POI data were obtained from Baidu Maps. Baidu Maps has similar functionality and popularity in China as Gaode Maps; but Gaode Maps has advantages in terms of more accurate data on road networks and buildings, while Baidu Maps contains large amounts of POI data. The POI data are divided into 19 categories, including shopping, hotels, food, tourist attractions, finance, real estate, cultural media and so on (He et al., 2018). Each POI contains four attributes: name, category, coordinates and classification. These data have been widely used in daily life and scientific research in China (Wu et al., 2018). POI data were obtained for 2015, 2017 and 2019 but, to be consistent with the building data, this paper used the 2017 data only. POI data is also obtained at no cost, and immediately after submitting the application.

Historic preservation zoning data. Major efforts have been made to select historic preservation plans, including all types of historic preservation planning information, and especially zoning maps, that have not been officially published on the Internet. Finally, historic preservation zoning data were collected from various resources, including official websites, news portals, newspapers, academic journals and personal contacts (Wu et al., 2018) with scholars, senior planners and others involved in landscape planning. Ultimately, historic preservation zoning data were obtained for twelve cities. Some parts of these cities have multiple historic preservation plans; in such cases the most recent plan was used as the reference for this study (Table 3).

Table 3 Historic preservation planning in twelve cities

CITY	YEAR	PLANNING POLICY
Beijing	2002	Beijing's Conservation of Historic Cultural Cities
	2011	Beijing's Conservation of Historic Cultural Cities for the 12th Five-Year Plan Period
	2016	Beijing's Conservation of Historic Cultural Cities for the 13th Five-Year Plan Period
Chengdu	2015	Chengdu's Conservation of Historic Cultural Cities
Guangzhou	2014	Guangzhou's Conservation of Historic Cultural Cities
Nanjing	2010	Nanjing's Conservation of Historic Cultural Cities
Hangzhou	2001	Hangzhou's Conservation of Historic Cultural Cities
Qingdao	2011	Qingdao's Conservation of Historic Cultural Cities
Shanghai	2017	City Comprehensive Planning of Shanghai (Conservation of Historic Cultural Cities)
	2019	Shanghai's Conservation of Historic Cultural Cities
Shenyang	2011	City Comprehensive Planning of Shenyang (Conservation of Historic Cultural Cities)

Suzhou	2017	Suzhou's Conservation of Historic Cultural Cities
	2013	Suzhou's Conservation of Historic Cultural Cities
Tianjin	2013	Tianjin's Conservation of Historic Cultural Cities, Town and Village
Wuhan	2010	Wuhan's Conservation of Historic Cultural Cities and
	2009	Wuhan's Conservation of Historic Cultural Cities and Historic Cultural streets in Main Urban Areas
Changsha	2003	Changsha's Conservation of Historic Cultural Cities
Chongqing	2014	Chongqing's Conservation of Historic Cultural Cities

4. Evaluation, optimization, and discussion

4.1 The adaptability of the urban landscape index

A three-stage t-test evaluation of the data was carried out. Evaluation 1 considered whether there is a significant difference in the urban landscape between the inner zoning and the outer zoning. If the t-test result is significant, the scope of the protected area is reasonable. Evaluation 2 considered whether there is a significant difference in the urban landscape between the inner zoning and the outermost zoning within the designated boundary. If the t-test result is not significant, the range of the zoning is appropriate; otherwise, it is too large. Evaluation 3 considered whether there is a significant difference in the urban landscape between the inner zoning and the adjacent block outside the zoned area. If the t test result is significant, the range of the protected area is appropriate; otherwise, it is too small. The results are shown in Figure 5.

Analysis of the 37 indicators revealed that not all were effective in assessing urban historic preservation zoning, and some could not be used to compare the differences among historic preservation zones and other areas. Three criteria were therefore used to filter out indicators that are not applicable: first, those with insignificant results in Evaluation 1; secondly, those with insignificant results in Evaluation 2; and finally, those with significant results in Evaluation 3.

In terms of all the 12 sample cities, most of the useful indicators were associated with the category of urban land use. This result was unexpected. Traditional typological and morphological research to assess urban development has mainly focused on planar urban patterns and architectural textures. However, these results show that the most significant differences between historic preservation zoning and other urban areas are due to land use, especially for CR_GS and SA_GS, which are the best two indicators as their location in the upper left quadrant of Figure 5 suggests. In addition, SA_IN, CR_PU and CR_TR also performed well. In terms of the land-use intensity, building expandability is an important indicator. In addition, there are several relatively effective indicators of city planning (in the upper left quadrant), such as RIQ and MABA.

Conversely, some indicators are not applicable to this study because they reveal no differences between areas inside and outside the designated historic preservation zones.

These indicators are the FD, SCR and MBE in the block pattern class; the BDE and BDD in the building base class; and the AWBSCR in the architectural two-dimensional form class. Notably, although most of the indicators in the land-use function class perform well, the two indicators of commercial land use are not applicable.

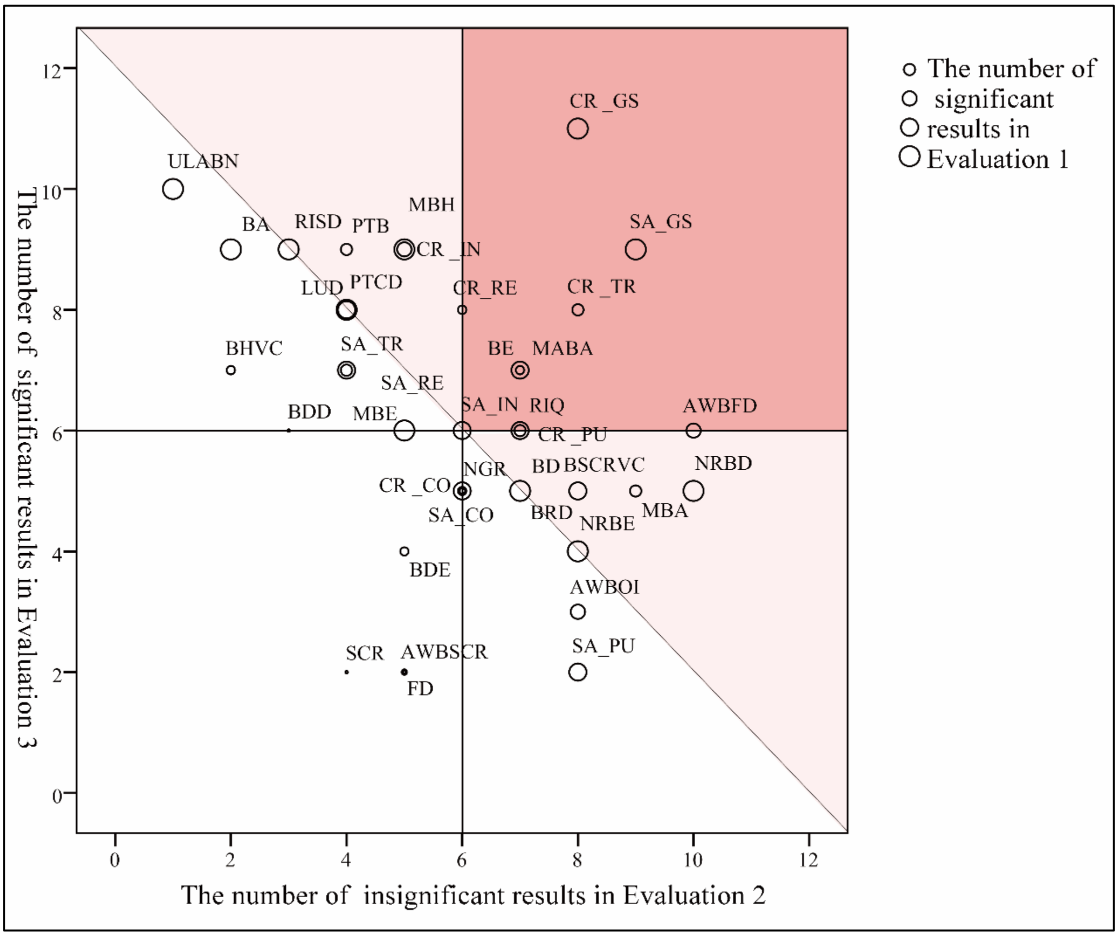


Figure 5 The performance of urban landscape indicators

4.2 Which cities are most appropriately zoned?

The historic preservation zoning in the sample cities was assessed in two scenarios: first, including all urban landscape indicators in the evaluation model, and secondly, including only the most useful urban landscape indicators (see Section 4.1) in the evaluation model. The results were mainly in line with expectations, but there were also some unexpected findings.

In the first model, the sample cities were divided into three categories. As shown in Figure 6, the historic preservation zoning of the cities (Beijing, Chengdu, Shenyang, Tianjin, and Qingdao) in the upper right-hand quadrant (shaded red) is generally appropriate~~ly~~. In other words, the urban landscapes in the historic preservation zones in these cities are significantly different from those outside the zoning boundaries and are insignificantly different from those at the inner edge of the zoning boundaries. Beijing is particularly prominent among these cities in Evaluation 1, with 41 significant indicators. Conversely, Chengdu and Shenyang have few significant indicators in Evaluation 1. The historic preservation zones in the cities (Changsha, Hangzhou, and Wuhan) located in the upper left-hand quadrant (shaded green) are likely to be smaller than would be appropriate. These three cities are very similar, with few significant indicators in Evaluation 1. The opposite phenomenon occurs in the lower left-hand quadrant (shaded blue), where the urban landscape within the historic preservation zones in these cities (Suzhou, Nanjing, Shanghai, and Guangzhou) differs from that in areas adjacent to the zoning boundaries and the difference is large compared with urban landscape at the inner edge. Therefore, the preservation zones are likely to be too large. Notably, the cities in the blue quadrant performed well in Evaluation 1, in stark contrast to the cities in the green quadrant.

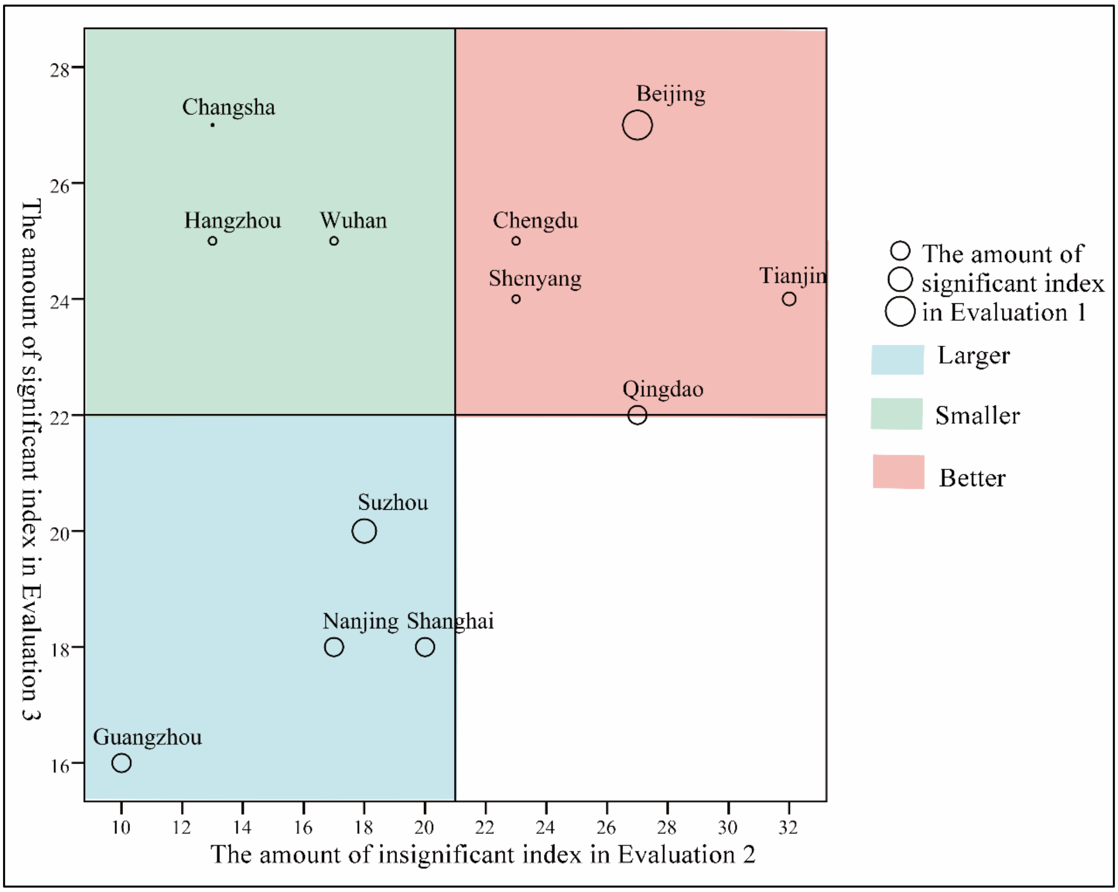


Figure 6 The evaluation results based on all the urban landscape indicators

In the second model, the evaluation results are similar to those of the first model but again with some unexpected findings (Figure 7). In the first model, the four cities in the red quadrant (Beijing, Chengdu, Qingdao, and Tianjin) and the three cities in the green quadrant (Hangzhou, Changsha, and Wuhan) did not change and remained in the original quadrants as in Evaluation 1. The changes were mainly reflected in the cities in the blue quadrant. After removing the unimportant indicators, Suzhou moved to the red quadrant, and the historic preservation zoning in the city was evaluated as improved. The most intriguing city was Nanjing, which was located in the unshaded quadrant based on the second model. The implication is that there were no significant differences in the urban landscape between historic preservation zones and the neighbouring areas. Thus it is impossible to determine whether the historic protection zone of Nanjing is large or small. Neither could it be determined whether the zoning had any positive impact on the landscape, or whether the boundary had been located in the most appropriate place. Based on the variables examined here, there seems to be no logical basis for this designation boundary.

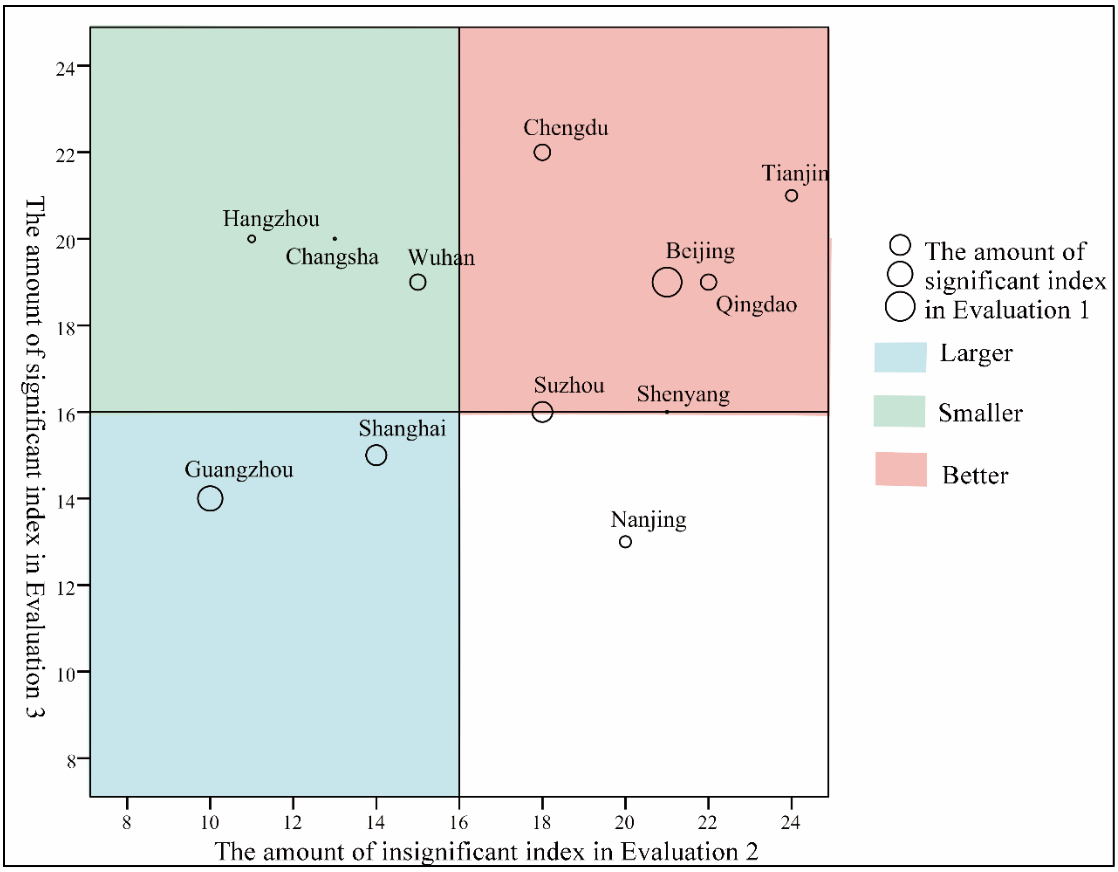


Figure 7 The evaluation results based on selected urban landscape indicators

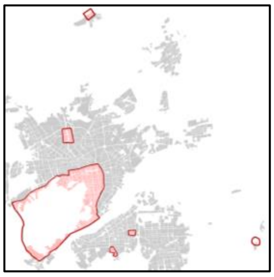
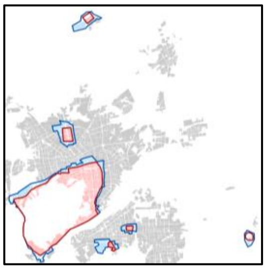
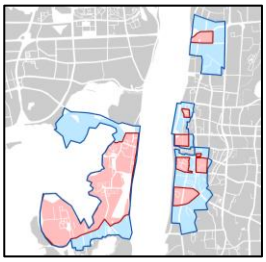
4.3 Optimizing historic preservation

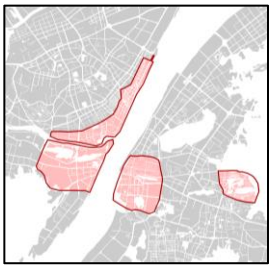
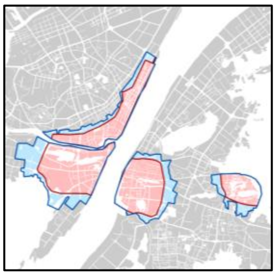
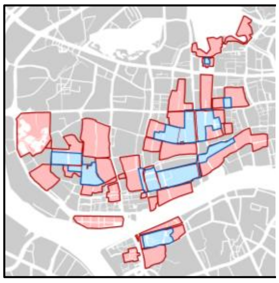
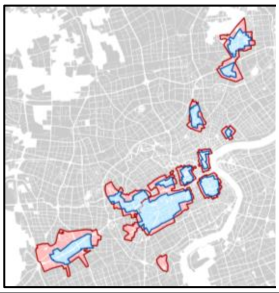
According to the above evaluation results, three cities have smaller historic preservation zones than seems ideal (Hangzhou, Changsha and Wuhan), while those of two cities

(Guangzhou and Shanghai) are larger than seems necessary. According to the analysis framework, similar urban landscapes should be divided into the same zoning. We therefore adjusted the historic preservation of the above five cities.

The optimization of historic preservation is divided into three steps: (1) Taking the block as a basic unit to achieve overall protection; (2) Counting the number of significant urban landscape indicators after the boundary optimization; (3) Comparing the results of the urban landscape evaluation, before and after of historic preservation optimization (Table 4).

Table 4 Optimizing historic preservation in five cities

Cities	Status quo (Red)	Optimization (Blue)	Urban landscape (Status quo/Optimization)		
			Evaluation1	Evaluation2	Evaluation3
Hangzhou			27/28	11/18	20/21
Changsha			24/26	13/21	20/22

Wuhan			25/28	15/26	19/19
Guangzhou			31/31	10/16	14/17
Shanghai			30/30	14/18	15/16

According to Table 4, the t-test results of urban landscapes are generally better by optimizing the historic preservation boundaries. Taking Hangzhou as an example, the existing historic preservation zone was assessed as small. After increasing the scope of the conservation areas, the number of significant urban landscape indicators surges to 18 (by 7) in Evaluation 2, while it increases to 28 and 21 in Evaluation 1 and Evaluation 3. In summary, big data technology provides a convenient and widely applicable approach~~es~~ for the evaluation and optimization of urban historic preservation zoning decisions.

4.4 The continuity of historic preservation

The urban landscape, broadly defined in both academic and practice contexts, is home to one-half of the global population, a proportion which is rapidly growing. In 1980, 1.731 billion people worldwide, i.e. 39% of the world population, were living in cities. In 2015, the number had increased to 3.968 billion (54%). According to some projections, the urban share of the world population will grow to 6.419 billion (66%) by 2050 (urbanet, 2016). Although there are some suggestions that preservation is an elite activity and should be abandoned in favour of seeking better living environments for all, historic urban landscape preservation has been considered an important aspect of zoning, and therefore of urban management, in most industrialized and many developing countries. The formal delimitation, and subsequent management, of preservation zones thus becomes a significant urban issue.

To provide a desirable standard for reasonable evaluation, the urban landscape indicators that had been identified were filtered. The results show that designated urban preservation zones may be too large or small, resulting in inadequate protection or wasted resources. Such evaluations can determine the overall quality and specific advantages and weaknesses of historic preservation in specific urban contexts. This evaluation provides a valuable opportunity to discuss how to improve historic preservation zoning.

This research suggests that the historic preservation zoning in Beijing is the most appropriate among the 12 cities evaluated, and that in Nanjing is the most difficult to justify. Beijing established urban master plans in 1983, 1993, 2005, and 2017 (Figure 8). The basic data used in this study are from 2017, but the 2017 version of the Beijing master plan has not been officially released at the time of writing, so the content related to historic preservation zoning in the 2005 urban master plan was assessed. The four versions of the zoning specifications were compared, and it was found that the historic protection plan in Beijing is very consistent (Su and Wall, 2014). In general, the plan reflects the typical characteristics of the urban landscape in China (e.g. building units, building groups and urban areas). Due to the consistency among the multiple versions of the historic preservation zoning plan in Beijing, protected areas with distinct features have been formed, and the urban landscape is significantly different inside and outside these protected areas. The history of Beijing’s preservation zoning from one plan to the next also reflects the general tendency in many countries to enlarge protected areas from one plan period to another.

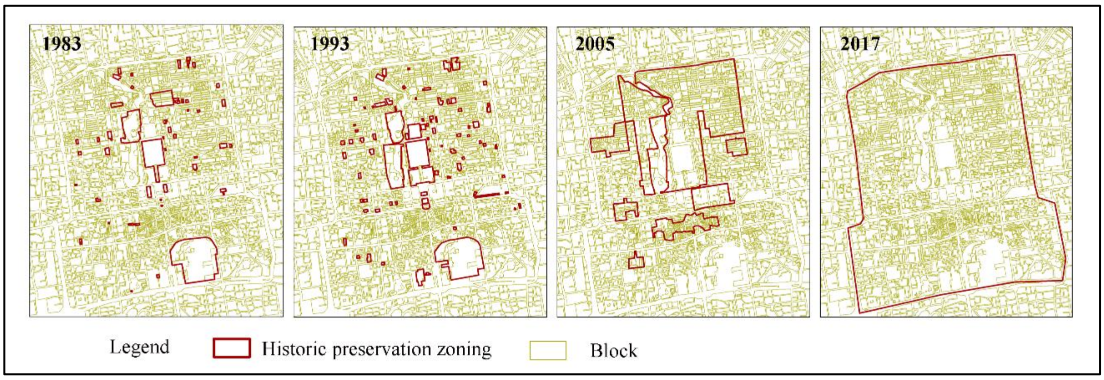


Figure 8 Historical preservation zoning in Beijing

The situation in Nanjing is very different to that in Beijing. Although Nanjing also established historic protection plans in 1984, 1992, 2004 and 2010 (Figure 9), it is surprising that the preservation zones differed so considerably between these plans.

What was perceived as valuable and worth zoning in one plan period changed almost completely in the next, and there is neither the consistency nor the overall growth and agglomeration of the zoned area that is seen in Beijing. This difference is likely to be the main reason why there is no significant difference between the urban landscape inside and outside the historic preservation zones. This calls into question the overall effectiveness of the zoning in Nanjing. This discussion of Beijing and Nanjing demonstrates that the policy evaluation using big data variables alone does not explain the differences observed; and additional information, in this case from the plan documents themselves, is required.

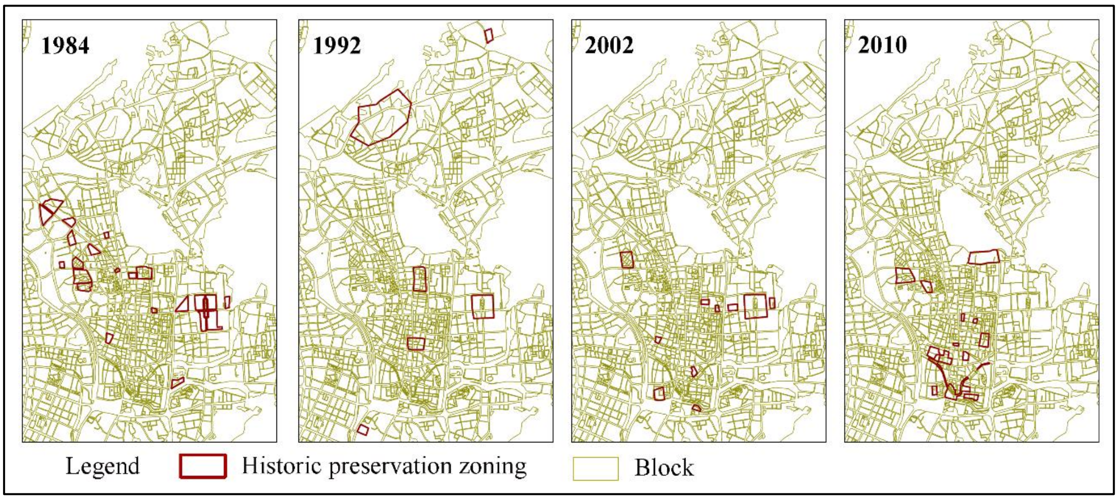


Figure 9 Historical preservation zoning in Nanjing

5. Conclusion

From individual structures to building groups and indeed the wider historic landscape in urban areas, urban historic preservation has received increased attention and emphasis in urban planning in many countries from at least the mid-twentieth century. In a global context, the attention to urban landscapes has evolved into protection activities, especially as stimulated by the UNESCO World Heritage Centre, which published the report "New life for historic cities: The historic urban landscape approach explained" in 2013 (Yeh et al., 2015; Taylor, 2016). Several studies have debated that all components of the urban landscape should be preserved regardless of whether they have outstanding value for global, national, and local representativeness. Preservation zoning practices are generally well supported through conservation theory. But their implementation often remains an unknown quantity, with little or no systematic evaluation of types and rates of change and hence the effectiveness of zoning, boundary delineation and area management.

This research establishes a technique for the quantitative analysis of urban landscapes by combining the traditional Conzenian framework with the rapidly-emerging availability of relevant geographic big data. This technique can not only evaluate the rationality of previous urban historic preservation zoning but also guide future urban heritage protection practices. This method evaluates preservation zones according to a landscape approach, which enables estimations of the quality of zoning, including the effectiveness of past plan implementation, to guide future processes. This evaluation method thus functions as a learning reference for determining zoning guidelines.

This research provides a set of urban landscape quantitative measurement techniques and historic preservation assessment methods. Taking 12 Chinese metropolises as examples, the historic preservation zoning has been evaluated using t-tests. The results show that, first, not all urban landscape indicators are applicable for evaluating historic protection; secondly, in sample cities such as Beijing, Qingdao, Suzhou and Chengdu, the preservation zoning seems appropriate; and finally, the historic preservation zones in other cities are too large or too small – and therefore likely to be ineffective or inappropriate. A comparison of the results for Beijing (the best case) and Nanjing (the most ambiguous case) suggests that effectively delineated and distinctive preservation zones are necessary for urban landscape protection and can be established by reviewing previous protection plans.

Reviewing the big data of the urban landscape indicators would also allow monitoring of landscape change, as change is both inevitable and necessary even in preserved areas. Such longer-term monitoring is rare and, using traditional data, is very time- and resource-consuming (Larkham, 1992). This would provide hard evidence for reviewing the effectiveness of preservation policy and zone boundaries.

This study contributes to the current knowledge regarding urban landscapes. In the Conzenian, Muratorian and Versailles schools of thought, the block is usually regarded as the main urban landscape (or townscape) unit. For example, three components (ground plan or two-dimensional layout, building forms, and the pattern of land and building utilization) are used to assess the landscape characteristics with substantial historical and cultural context. As these components change over time, the urban landscape has been historically stratified (Maretto, 2005), with distinctive features created in each period and varying from area to area. Therefore, traditional urban landscape studies require extensive collections of topographic maps, land-use maps, urban maps, etc. However, these long-term runs of accurate maps are scarce in many countries and regions. Therefore, the detailed study of urban landscapes is largely subject to this limitation. The geographic big data-based approach provided in this paper measures the urban landscapes themselves, and advances both methodological and technical aspects of urban landscape evaluation.

Finally, this research has made considerable contributions to Chinese historic preservation. Currently, China is suffering from a series of deep-rooted problems related to heritage protection planning. First, urban conservation methods mainly stem from land-use planning. Urban heritage is often regarded as a static physical entity, resulting from methodologies relying on descriptive approaches rather than deduction (Whitehand et al., 2011). In reality, at this stage the development of urban heritage policy and practice in China would benefit more from additional empirical assessments, rather than conceptual analysis, to provide a sound evidence base. Secondly, policy and practice regarding historic protection are not currently emphasized in China, leading to fuzzy criteria for delineating historic protection boundaries and prioritizing conservation (Wu et al., 2019). This approach does not support the credibility of much current preservation zoning and its effective implementation. There is room for improvement.

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