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Study on the spatial characteristics of urban heritage in Xi'an city's historical core area

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Abstract. The purpose of this paper is to study the spatial characteristics of urban heritage in the historical core area of Xi'an, China. The focus of the research is on the in-depth analysis of the changes in urban form in various historical stages, the functional distribution of urban heritage that remains, and the evolution of the boundaries, centres, and axes of urban space. These factors are the main elements that constitute the core of the city. Through in-depth analysis, we can clearly outline the evolution path of urban space in historical continuation and era change. This study adopts comprehensive research methods, including literature analysis, map visualisation, map overlay, and multiple research methods such as space syntax analysis. From the perspectives of functional complexity, spatial continuity, and space syntax, it comprehensively and systematically expounds and studies whether the spatial characteristics of urban heritage sites have gradually lost their core status in the process of urbanization. Such research can not only better understand and recognise the intrinsic value of urban heritage but also provide valuable experience for the sustainable development of urban heritage. The research results are of great significance to heritage protection, urban planning, and policy formulation and help to protect cultural heritage, guide urban planning, and provide substantive recommendations to policymakers.

1. Introduction

With the advancement of globalisation, people's awareness of respect for and protection of historical culture has continuously improved, and the protection of urban heritage has become a global issue. Local governments are seeking to find a balance between economic development and heritage protection [1,2]. Globalisation has promoted the development of international tourism, and urban heritage has become an important resource to attract tourists from all over the world [2].

However, the increase in tourist flow also brings new challenges to the management and protection of urban heritage, and many tourists may cause physical damage to urban heritage sites or put pressure on local ecology and the community environment [3]. Urbanisation also brings changes in architectural styles and urban layouts, which can affect the visual and spatial context of urban heritage [4].

The research on the impact of urban heritage on urban spatial pattern has formed a rich theoretical basis. Early studies in urban geography and anthropology have recognized that urban spatial form is the physical expression of social, cultural, economic, and political processes [5,6]. The distribution of urban heritage plays a very important role in shaping the urban pattern, which has been confirmed by



many scholars [7]. In "The Image of the City" (1960), Kevin Lynch discussed the impact of urban heritage on the image of urban space. He believes that urban heritage is an important part of the city's "image elements", thus affecting the organization of urban space and the public's perception of the city [8]. Not only that, but the distribution of urban heritages will also have a profound impact on the surrounding community structure and residents' lifestyles. Urban heritages are not only the bearers of urban history and culture but also the embodiment of urban space and time. The distribution of urban heritages, protection, and revitalization directly affect the spatial pattern of the city [9]. Heritage sites usually have a profound connection with the social, historical, and cultural aspects of the city. They have a decisive impact on the positioning of urban functional areas, the layout of transportation networks, and the construction of urban landscapes. Heritage is not just a legacy of history; it is still active in the modern city, becoming a bridge connecting the city's history and modernity [10]. For example, in some ancient cities in Europe, the city centre often gathers many historical buildings. The existence of these buildings allows the city to retain the original street network and functional layout, and it also gives the city the unique urban landscape and cultural atmosphere of these cities [11].

This study will shed light on the evolution of urban form, The spatial form mentioned in this study is not only the combination and distribution of various physical elements in the space but also the spatial form of the city under the influence of complex social culture. The evolution of the city also reflects the development of society and the evolution of the environment [8,9].

Under the influence of many factors, the spatial form of the city is also constantly changing, forming different spatial form characteristics in different historical periods, and each spatial form is constantly superimposed under the development of history [11,12].

Research on the evolution of urban form can not only present the evolution process of urban material space but also reveal the internal laws of many social and cultural factors and excavate the precious urban heritage left by the city in the evolution process, to realize the protection and sustainable development of historical urban areas continuous development [13,14]. Urban heritage plays an important role in the city. Urban heritage is the intangible heritage such as history, culture, and buildings preserved in the process of urban development that has unique historical value, cultural significance, and artistic expression [15]. Urban heritage is not only a symbol of urban identity but also an important part of urban spatial structure and form.

The main research question of this study is whether the spatial characteristics of urban heritages have lost their centrality with the process of urbanisation. The spatial characteristics of urban heritages are a key field in the study of urban morphological patterns in the historical core area, which play an important role in understanding the history, culture, and social identity of the city [4]. This study will analyse the following three points:

Complexity of functions, research on the functional characteristics and remains of urban heritage in various historical periods. The urban heritage in the historical core area often carries multiple functions, such as commerce, residence, entertainment, religion, etc., reflecting the integration of history and modern life as well as the complexity of social culture [16].

Continuity of space, to study the structural form of the city and the status quo of the remains in various historical periods. Urban heritage usually embodies a kind of historical continuity and usually reflects the development trajectory of the city from the early days of its establishment to the process of modernization. Because of its specific historical background, it has a unique spatial organisation structure in the spatial layout [17]. This study will analyse the changes in the urban spatial structure and the status quo of the remaining urban sites from the perspective of the city's boundary elements, central elements, and axis elements.

Accessibility of space, counting the location of urban heritage in each historical period. We will use spatial statistical tools to analyse the location of urban heritage in various historical periods to study the spatial layout characteristics of urban heritage. We will pay particular attention to the accessibility of heritage spaces. In space syntax theory, the accessibility of a place represents its importance in the spatial network [18,19], then reveal how urban heritage maintains its core position in the process of urbanisation. Accessibility is defined as the behaviour of people in appropriate spaces

within local and global networks. As a configuration of urban public spaces, accessibility refers to the ease of travel to destinations. Evidence suggests that cities with lower connectivity and visibility have less static urban activity [20].

2. Methodology

2.1. Research object, time and scope limit

As the ancient capital of the thirteen dynasties, Xi'an has many urban cultural sites that have been preserved to this day. The historical and cultural heritage of Xi'an has a profound impact on the urban spatial layout [21]. These sites constitute an important part of the urban spatial layout of Xi'an. For example, the city wall of the Ming Dynasty is not only a historical mark of the city but also has a direct impact on the street pattern of the modern city [22]. Xi'an is one of the earliest places in the world to achieve urbanisation, the starting point of Chinese civilization and the Silk Road, and one of the four ancient capitals of ancient civilizations in the world [23]. Its rich and diverse urban heritage and unique spatial characteristics make it an ideal case for studying the spatial characteristics of urban heritage in historic core areas.

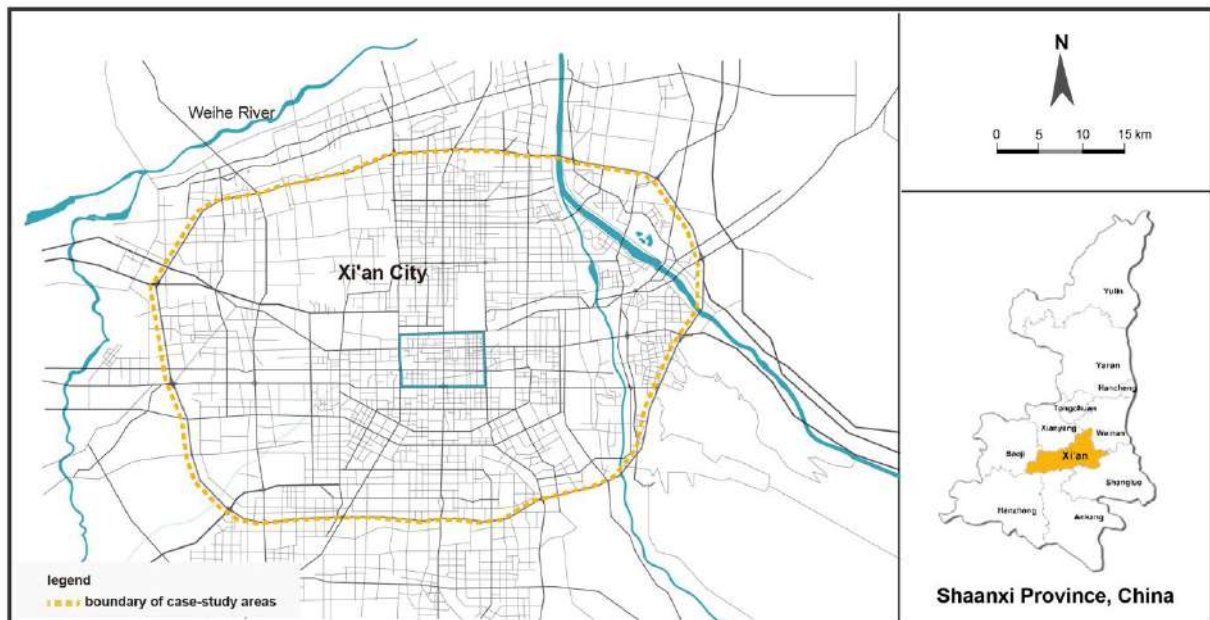


Figure 1. The research area of case study. (Source: drawn by the authors)

The urban development of Xi'an has gone through two stages: the period of the construction of the historical capital and the period of the construction of the historically important town [24]. The period of historical capital construction includes the construction of Chang'an (now Xi'an) from the Han Dynasty to the Tang Dynasty; the period of historically important towns includes the construction of Xi'an from the Five Dynasties to modern times. The time range of this research is from the Han Dynasty to the Ming and Qing dynasties Xi'an city development. The period of the historical capital city was the golden period for the development of Chang'an. As a political, economic, and cultural center, the city's organizational system reached an unprecedented peak. The opening of the Silk Road also made Chang'an international metropolis. During The construction period of the historic town, as the political center moved eastward, although Xi'an was not the capital city due to its important geographical location, it was still an important town to control the northwest region, as shown in table 1.

The research scope is the central urban area of Xi'an, that is, the urban construction area within the motorway around the city. Mainly study the heritages of the capital city of Han, the heritages of the capitals of the Sui and Tang Dynasties, the heritages of the capitals of the Five Dynasties to the Yuan Dynasty, and the heritages of the capitals of the Ming and Qing Dynasties. Therefore, this area contains highly compressed historical information. The research in this area is typical for the analysis of Xi'an's urban pattern and heritage spatial characteristics, figure 1 shows the scope of this study.

Table 1. Xi'an's development stages in various historical period. (Source: drawn by the authors)

time	Han Dynasty	Sui Dynasty Tang Dynasty	five Dynasty Song Dynasty Yuan Dynasty	Ming Dynasty	Qing Dynasty
	The construction period of the historical capital		The construction period of the historic town		
Urban area	Construction Period of the Han Dynasty	Construction Period of Sui and Tang Dynasties	Construction Period of the Five Dynasties to Yuan Dynasty	Construction Period of Ming and Qing Dynasties	
	City Sites of Han Dynasty	City Sites of Sui and Tang Dynasty	City Sites of five Dynasties-Yuan	City Sites of Ming and Qing Dynasties	

2.2. Collection of urban heritage data

This study focuses on collecting documents related to the historical and cultural heritage of Xi'an city, including maps of various historical periods, historical texts, planning documents, etc. Through the analysis of these documents, geographical features such as city walls, city gates, city boundaries, city centres, city axes, and various functional elements from various historical periods were collected. A total of 115 sites were selected for research, of which 74 can be found on the map, and the remaining 41 are urban imprints, as shown in table 3. Classifying historical heritage across different epochs, as shown in table 2.

Table 2. Classification of historical heritage. (Source: drawn by the authors)

Classification of historical heritage elements					
protection level	Existing Functional Properties				
national level	Heritage Park	Tombs	Building	Stone carving	others
provincial level					
City level					

The historical document research method is an important research method widely used in history, sociology, anthropology, and other disciplines. Its main purpose is to understand and explain historical events, processes, or phenomena through in-depth analysis and interpretation of past documented records [25]. It mainly involves searching, collecting, organizing and analyzing data. Using historical documents and maps is an important tool for understanding changes in urban form [26,27,28].

The graphic overlay method is used for analysis. A graphic overlay usually displays more than two kinds of information in the same graphic space and can compare and analyse the connection and difference between these data spatially and visually.

Table 3. Statistical table of cultural relics protection units in the main urban area of Xi'an (after screening). (Source: drawn by the authors)

Level	Name	Quantity
National culture relic protection unit (Including world cultural heritage)	Weiyang Palace Ruins in Chang'an City of Han Dynasty, Changle Palace Ruins in Chang'an City of Han Dynasty, Jianzhang Palace Ruins, Xuanping Gate Ruins, Bacheng Gate Ruins, Fu'an Gate Ruins, Xi'an Gate Ruins, Zhicheng Gate Ruins, Luocheng Gate Ruins, Qingming Dynasty Gate Square, Anmen Square, Hancheng Lake Site, Mingde Gate Site, Yanping Gate Site, Daming Palace Site of Tang Chang'an City, Big Wild Goose Pagoda, Xi'an Forest of Steles, Duling, Jianzhang Palace Site, Baqiao Site, Sui Dynasty Daxing, Tang Chang'an City Ruins (including Qinglong Temple Ruins), Xi'an City Wall, Xi'an Bell Tower, Drum Tower, Ming and Qin King Tombs, Revolutionary Park, Taiye Pool Ruins, Huajue Lane Mosque, Xi'an City God Temple, Guangren Temple, Anyuan Gate, Anding Gate, Yongning Gate, Changle Gate,	36
Provincial Cultural Protection Unit	Temple of Heaven Ruins, Daxingshan Temple, Wolong Temple, Baxian Nunnery, Dugong Temple, Taiyechi Ruins, Xingqing Palace Ruins, Ming and Qin Palace Wall Ruins, Daren Ruins, Wanshou Temple Pagoda in Xi'an, Northwest Yiyin Former Site, Yang Hucheng Cemetery, Daren Ruins The former site of Huaya Mill, Daxuexiang Mosque, Xiaopiyuan Mosque, Pagoda of Baoqing Temple, Dongyue Temple, Guanzhong Academy, Wangji Temple, Ganye Temple Ruins, Xiwutai Yunju Temple, Xi'an Jiaotong University Han Mural Tomb, Yangwuzhuang Cemetery and Ancestral Hall,	18
Municipal Cultural Protection Unit	Dapiyuan Mosque, North Guangji Street Mosque, Wanshou Temple Tower, No. 14 Residential House at North Courtyard Gate, Wuxing Street Catholic Church, No. 40 and No. 39 residential houses in Ludang Lane,	12
Heritage point	Shiqu Pavilion Ruins, Tianlu Pavilion Ruins, Xiangzi Temple, Tangfang Street Catholic Church, Residence No. 77 of Xiyang Temple, Residence No. 125 of Huajue Lane, Ancient Mosque of Sajin Bridge, and Shiyingli Temple of Primary School	8

2.3. Map visualization of urban heritage data

Urban construction is a continuous, dynamic process. Figure 2 summarises the key time nodes of urban construction in various historical periods. In the historical period of Han Chang'an city, the city map from AD 20 to AD 22 (Wang Mang period) was selected as the research object because it experienced four construction climaxes, and Han Chang'an city finally formed a complete form. The construction of Chang'an city in the Sui and Tang Dynasties has gone through two periods, namely, Sui Daxing and Tang Chang'an. Select the map of Tang Xuanzong's reign as the research object. After four previous constructions, Tang Chang'an city formed the most complete urban form. Since the Five Dynasties, Xi'an has ceased to be a historical capital. From the Five Dynasties to the Yuan Dynasty, the urban form has not undergone essential changes, and the city scope is consistent with that of the Five Dynasties. There are few urban heritages in this period, which are not typical for research, so no specific analysis of map visualisation was done in the study. During the Ming and Qing Dynasties, urban construction relied on the expansion of the Song and Yuan Dynasties, so this study will select the city map of Xi'an during the construction of the Qing Dynasty. The three periods selected above are the key analysis time stages of this study, and the corresponding urban maps of the three periods are also the main analysis objects of this study.

Specifically, the remaining city walls, city gates, city centres, and city axes are marked on the maps of each historical period. Analyse urban form and function in historical periods. We can study how the existing sites are protected and utilised, what form they exist in (such as parks, museums, residential areas, etc.), and analyse how they affect the spatial form and social functions of modern cities.

Through the processing of map visualisation, we can intuitively observe, with the evolution of history, the characteristics of the distribution of heritages in each city and the status quo of the heritage

remains. Combined with relevant historical documents, the outline of urban form in different historical periods is visualised, the existing urban heritages are marked, and the analysis is combined with the current status of urban functions as shown in figure 3.

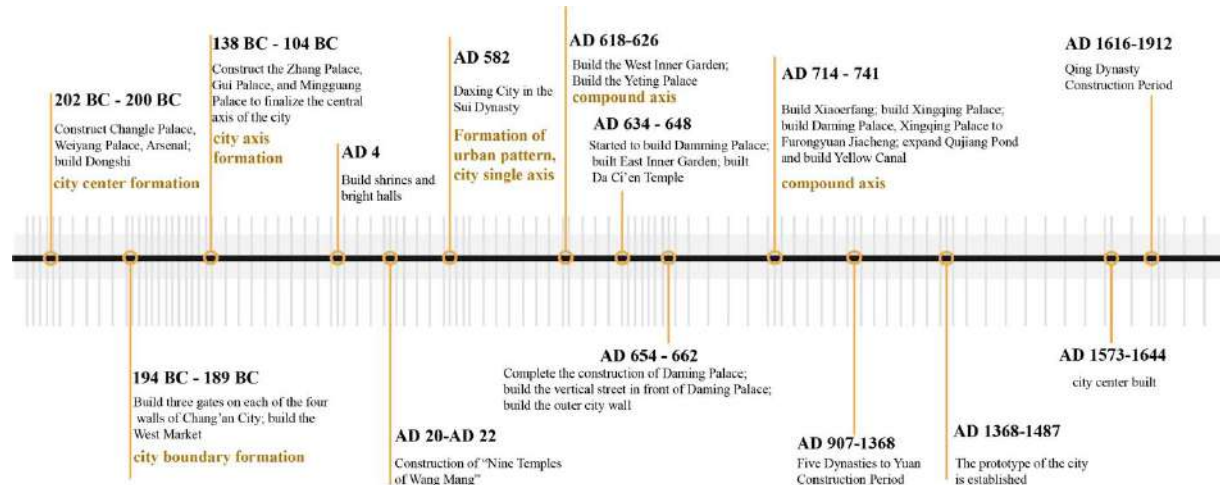


Figure 2. The important construction period of Xi'an (Han Dynasty to Qing Dynasty). (Source: drawn by the authors)

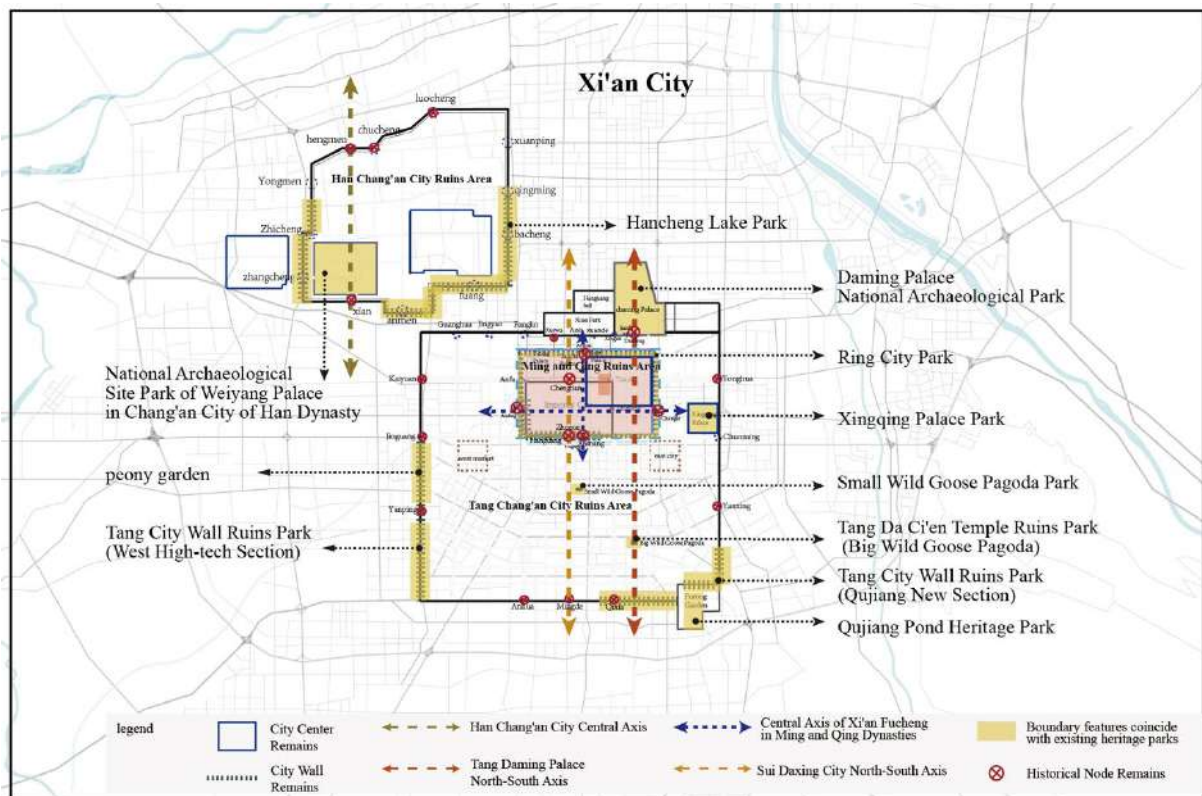


Figure 3. The overlay map of various historical elements in Xi'an. (Source: drawn by the authors)

2.4. Space syntax analysis

Accessibility is a central concept in the study of space syntax. Accessibility describes how easily a location can be reached from other locations. Hillier pointed out in his 1996 paper "Space is the

Machine" that the level of spatial accessibility directly affects the distribution of human activities and the use of urban space [29].

If this theory is applied to the study of urban sites, it can be speculated that past social and economic activities may also tend to occur in places with better spatial accessibility, and therefore, there may be more sites in these places. For example, in Paul Wheatley's 1971 book "The Pivot of the Four Quarters", by analysing the distribution of sites in ancient cities, he confirmed the impact of urban spatial structure (including accessibility) on the distribution of sites.

Obtain the latitude and longitude of each urban heritage through map data, and then use Seatable software to map the location of each urban heritage on the map to find out the characteristics of the heritage. Use the line segment map in space syntax to analyse the accessibility of the whole city and the characteristics of urban heritage distribution in the context of the city.

This research uses the depthmap software to conduct space syntax analysis on the road network in the main urban area of Xi'an and selects the integration value to judge the accessibility of the road network. The road data comes from the road network data in the central urban area of Xi'an in the 2020 "China's Major Cities Road Network Density Monitoring Report". Import the road network data into CAD software, create an axis model, and then import it into the depthmap software. Select the axis in the software map, after confirming that the created axis model is correct, select the line segment model to start road analysis.

2.5. Theory and research ideas

The purpose of studying the spatial characteristics of urban heritage is to promote its sustainable development. By collecting and filtering data, we visualise the distribution of urban heritage and study the spatial characteristics of urban heritage in the context of the city. The characteristics of heritage distribution in different historical periods are closely related to the social and cultural environment at that time. Our research aims to reveal whether the urban heritage in the historical core area has gradually lost its core position in the process of urbanisation by analysing the urban form, digging into the functions of urban heritage, and examining the changes in the boundaries, centres, and axes of urban space.

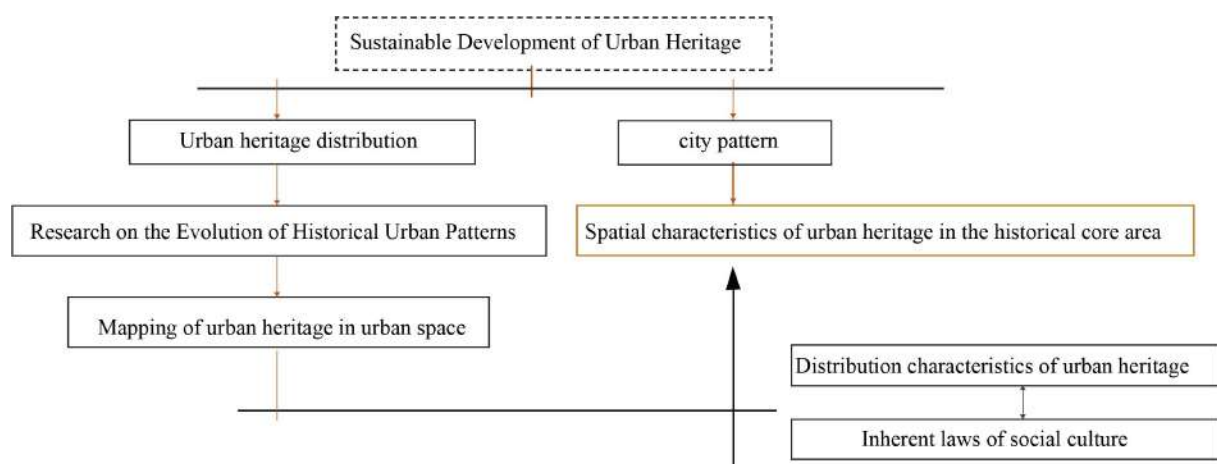


Figure 4. Research framework. (Source: drawn by the authors)

3. Case study

3.1. Explore the morphological evolution of cities.

According to whether Xi'an (ancient Chang'an) is the capital city, Xi'an can be divided into the period of historical capital construction and the period of historically important town construction, and the

urban evolution from Chang'an city in the Sui and Tang Dynasties to the prefectural city of the Ming and Qing Dynasties as shown in figure 5. During the Sui and Tang Dynasties (581–907 AD), Xi'an (Chang'an) was the capital of China and one of the largest cities in the world. The planning of Chang'an city is rigorous, and the urban layout is clear. The grid-type street layout is mainly adopted. This layout form is also known as the "building method". Specifically, in this design, the city is divided into grid-shaped blocks, each containing residences, shops, and public facilities. This layout aims to ensure the orderliness of the city while also providing the possibility of spatial expansion for the city. The design concept and urban form of Chang'an city in the Sui and Tang Dynasties provided the foundation for the subsequent urban construction of Xi'an. The city covers an area of 84 square kilometres and has a population of more than one million. The urban form of this period is mainly reflected in its regular street layout and large public buildings, such as Daming Palace, Big Wild Goose Pagoda, etc [30]. This change in urban form is mainly due to the strong national power and high level of urban planning during the Sui and Tang Dynasties.

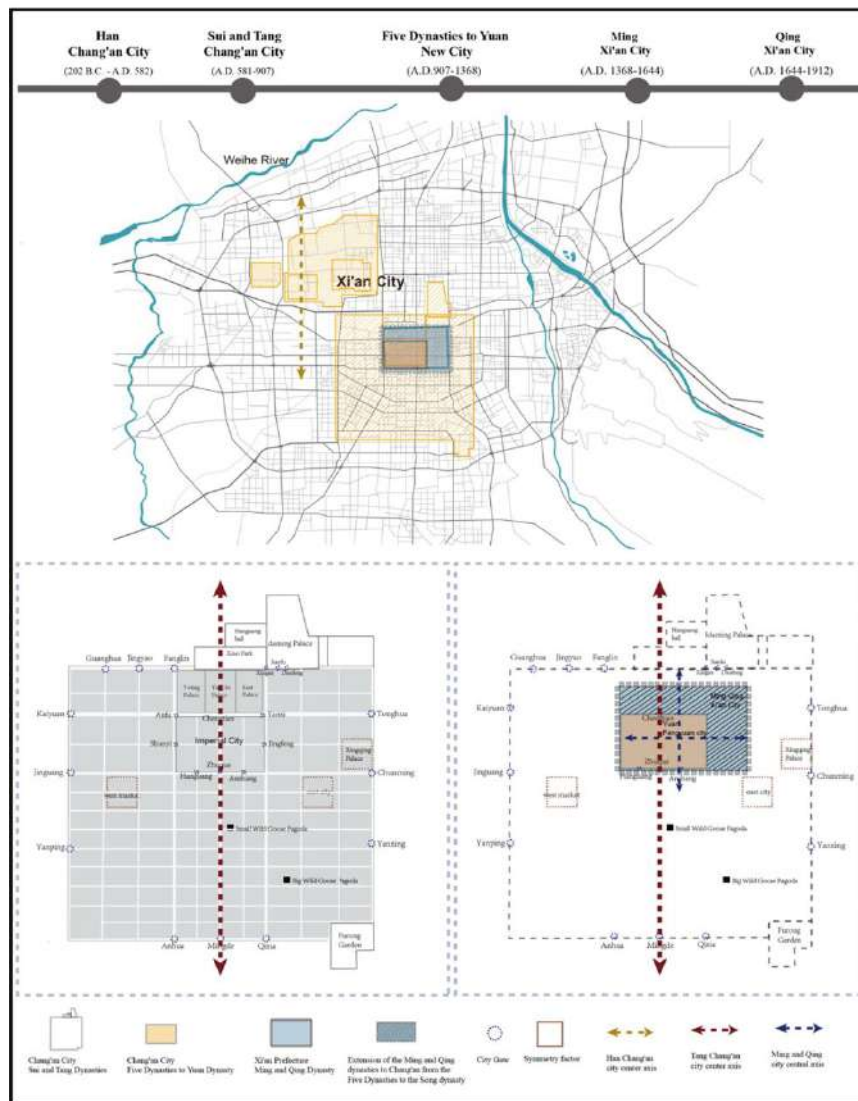


Figure 5. The research area of case study. (Source: the author draws based on Shi Nianhai’s “Xi’an Historical Atlas”)

Ming and Qing Dynasties (1368–1912 A.D.). The city of Xi'an in the Ming and Qing Dynasties was relatively small, with an urban area of about 14 square kilometres [31]. The urban form of this period is mainly reflected in the city's defensive buildings, such as city walls and gates. In addition, there were many important cultural heritage sites in Xi'an during this period, such as the Bell and Drum Tower, Muslim Street, and so on. This change in urban form was mainly due to the socio-political environment and cultural development during the Ming and Qing Dynasties. During this period, Xi'an expanded in scale, its functions became more complex, and more public and cultural facilities began to appear. This construction method not only continues the urban design concepts of the Sui and Tang Dynasties but also lays the foundation for the development of modern Xi'an [32]. Lu Simian, a well-known Chinese historian and urban research expert, once pointed out that "the city wall had a decisive influence on the shape and development of ancient cities. It defined the scope of the city, guided the layout of the city, and shaped the image of the city." In the study, the construction of the Ming City Wall in Xi'an was regarded as an important part of urban construction in the Ming and Qing Dynasties, which played a key role in protecting the city, planning the city, and shaping the image of the city.

There is a close interaction between the morphological features and the remains of the city, which together shape the form and function of the city [33]. The remains affect the morphological development, such as ancient city walls, historical buildings, archaeological sites, etc., which often have an impact on the morphological development of the city. By analysing the urban form outlines of Xi'an in various historical periods, it can be concluded that the development and construction of Xi'an were mainly based on the construction of the Sui and Tang Dynasties and the Ming and Qing Dynasties.

3.2. Functional characteristics and remains analysis of urban heritage.

The distribution of sites with different functions in each historical period is mainly divided into administration, defence, culture, religion, commerce, residence, worship, and gardens. A total of 115 urban historical sites have been counted as shown in table 4. Among them, the political functional sites mainly count the national and local administrative institutions, and the military defence mainly includes city walls, city gates, moats, and military institutions. Religious categories mainly include Taoism, Buddhism, Islam, and other religious spaces. Commerce includes city squares; residence includes palaces and civilian residences; sacrificial offerings include ancestral temples, ancestral halls, sacrificial buildings, and other sacrificial spaces; and gardens include royal garden spaces.

Table 4. Existing distribution map of urban heritage with different functions in each period. (Source: drawn by the authors)

Time	Administration	Defence	Culture	Religion	Commerce	Residence	Sacrifice	Gardens
Han	9	13	2	0	0	0	0	0
Sui and Tang	1	16	0	6	2	2	2	2
Five Dynasties to Yuan	1	5	1	4	4	0	0	0
Ming and Qing	3	10	5	13	6	5	1	2

In the functional heritages of Chang'an city in the Han Dynasty, the political, defensive, and cultural aspects are mainly reflected. These sites are usually protected and exhibited in the form of parks. For example, the sites that reflect political functions include Weiyang Palace Site, Changle Palace Site, Jianzhang Palace Site, etc. Among them, the Weiyang Palace Site and Changle Palace Site have become part of Han Chang'an National Heritage Park [34].

The functional heritages of Chang'an city in the Sui and Tang Dynasties mainly reflect aspects of administration, defence, religion, commerce, residence, sacrifice, and gardens. For example, the administrative site is dominated by the Daming Palace, and the protection method is mainly a site park, the defensive function includes elements such as city walls, city gates, and military institutions, which

strongly reflects the importance attached to the military defence system at that time. Religious and residential sites exist in the form of relic parks on the one hand and develop in the form of historical commercial blocks on the other. For example, Kaiyuan Temple contains commercial functions, and Muta Temple exists in the form of relic parks. The increase in the number of these sites also reflects the Sui and Tang Dynasties, prosperity of religion [35].

The functional heritages from the Five Dynasties to the Yuan Dynasty mainly involved five aspects: administration, defence, commerce, religion, and culture. Xi'an city in the Ming and Qing Dynasties, as the largest military town in northwest China, had functional sites mainly involved in administration, defence, commerce, residence, religion, culture, gardens, sacrifices, and other fields. Mainly historical and cultural blocks. The distribution and protection of such historical sites reflect the dynamic balance between the protection and use of urban historical and cultural heritage.

Summarises the statistics of the functional distribution of urban relics in each historical period, including the number of relics with different protection levels and the number of relics in the city centre, axis, and boundary. In terms of reflecting urban functions, during the Sui and Tang Dynasties and the Ming and Qing Dynasties, urban functions were rich, representing economic prosperity and political stability at that time, and there were many urban heritages. Of the urban remains representing the urban form and structure, only the remains of the Sui, Tang, Ming, and Qing dynasties are relatively complete as shown in figure 6.

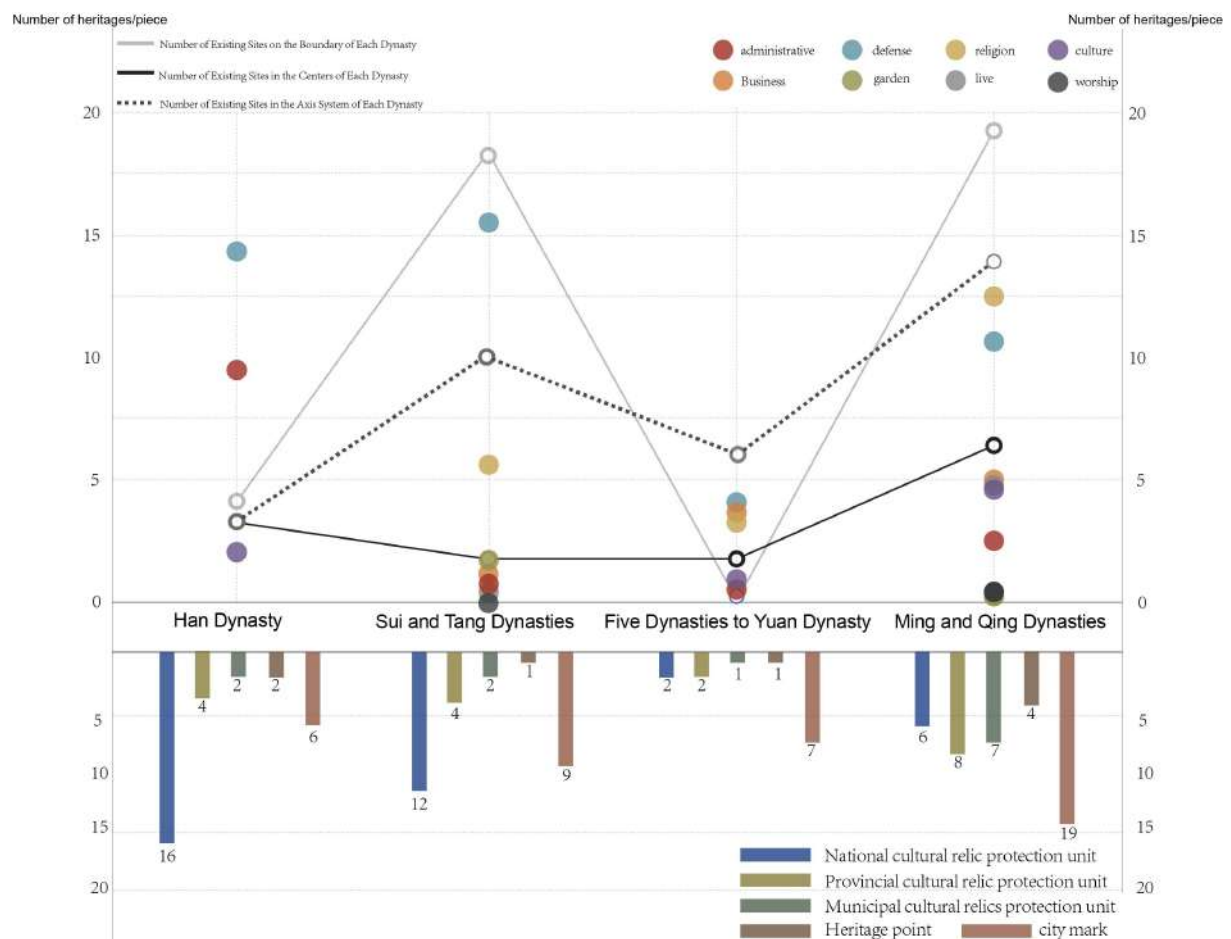


Figure 6. Based on the distribution of protection levels, function distribution, and urban morphological unit distribution of existing sites in different dynasties. (Source: drawn by the authors)

The urbanization process will not eliminate the spatial characteristics of urban sites in the historic core. On the contrary, these sites often maintain and enhance their spatial characteristics by being embedded in the urban environment and functions. The protection and rational use of heritage sites is an important task in the process of urbanization. For example, in the above-mentioned historical cities such as Chang'an city in the Han Dynasty, Chang'an city in the Sui and Tang Dynasties, Xi'an city from the Five Dynasties to the Yuan Dynasty and the Ming and Qing Dynasties, their sites have not only been well protected, such as existing in the form of parks, but also reasonably utilized. Such as the development of historical commercial districts.

In the process of urbanization, historical sites still retain their original spatial characteristics and inherit their original functions. For example, the heritages of Daming Palace and Kaiyuan Temple still retain administrative and religious functions [36]. Urbanization did not obliterate the spatial characteristics of the site, but instead strengthened its "dialogue" in different historical periods. For example, the increase in the number of religious sites in the Sui and Tang Dynasties reflected the prosperity of religion in that period, and the existence of Xi'an as a military center in the Ming and Qing Dynasties reflected the political and military background of that period.

In general, urbanization does not cause urban sites in the historic core to lose their spatial identity. On the contrary, through reasonable protection and utilization, the spatial characteristics and functions of the site can be continued and developed in the process of urbanization, becoming an important part of the city's historical and cultural heritage [37].

3.3. Morphological characteristics of urban structure and analysis of remains.

The boundaries, centres, and axes of cities in various historical periods are an important part of understanding the historical changes in urban form. From table 5, we can see that the number of remains in the Sui, Tang, Ming, and Qing Dynasties is relatively large, followed by the Chang'an city in the Han Dynasty, and the number of remains from the Five Dynasties to the Yuan Dynasty is small. Therefore, this study will focus on analysing the characteristics of urban morphology and structure in the Han, Sui, and Tang Dynasties and the Ming and Qing Dynasties. These elements express the structure, scale, orientation, and form of the city, revealing the city's physical character, functional organisation, and social, cultural, and historical context [8]. The city boundary depicts the extension and spatial limitations of the city, and its changes reflect the history of urban development and expansion. The city centre is the concentration of activities and the important core of urban form, and its changes reflect the evolution of the city's economic, social, and political functions. The urban axis reflects the direction and structure of the city, and its layout and characteristics have a profound impact on the image and spatial experience of the city [38]. The following will analyse the protection situation of the main urban area of Xi'an from the boundary elements, central elements, and axis elements.

Table 5. The number of structural and morphological characteristics of urban heritage in Xi'an.
(Source: drawn by the authors)

Time	City Boundaries	City Centre	City Axes
Han Dynasty	4	3	3
Sui and Tang Dynasties	18	2	10
Five Dynasties to Yuan Dynasty	0	2	6
Ming and Qing Dynasties	19	6	14

3.3.1 Element analysis of historical city boundary

The city boundary elements are mainly reflected in the city walls and moats of the ancient city of Xi'an. In ancient China, it belonged to the defence system, protecting people and property in the city from infringement. The boundary of the ancient city often also had strong symbolism. It was a symbol of

the city's status and rights, and it was also a display of the city's scale and image [39]. City boundaries can also play a role in separating spaces. The city boundaries of Xi'an in various historical periods mainly include the city walls of Chang'an in the Han Dynasty, the city walls of Chang'an in the Sui and Tang Dynasties, the city walls of Xi'an in the Ming Dynasty, Hancheng Lake, and the moat lake in Xi'an in the Ming Dynasty.

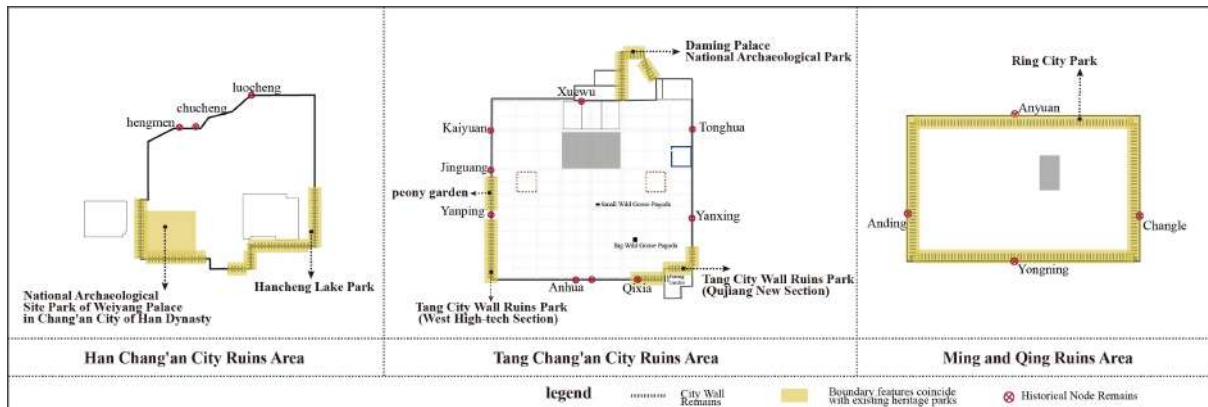


Figure 7. Analysis of the urban boundary elements of Xi'an in various historical periods. (Source: drawn by the authors)

Table 6. Remains of city boundaries in different periods. (Source: drawn by the authors)

Time	Historical Components	Existing Heritage Status
Han Dynasty	Han Chang'an City Wall	Han Chang'an City Wall Ruins and Outline
Sui and Tang Dynasties	Tang Chang'an city wall	Tang Chang'an city wall ruins and some city gates
Ming and Qing Dynasties	Guocheng City Wall	Ruins of city walls and moats of Ming and Qing Dynasties

As shown in figure 7, relying on the heritages park, the outlines of the city boundaries of Xi'an in various periods are relatively well preserved. The boundary shape of Chang'an city in the Han Dynasty is mainly defined by the outline area of the Han City Wall, which can define the east, south, and west boundaries of the Han City site. The outline of the northern boundary city wall no longer exists, but the city gate still exists. The southern section of the western city wall and the western section of the southern city wall of Han Chang'an city are included in the scope of the Weiyang Palace Archaeological Site Park, as are the southern section of the eastern city wall and the eastern section of the southern city wall. The section is included in the Hancheng Lake Heritage Park. The construction of Chang'an City in the Sui and Tang Dynasties went through two periods, namely the construction period of Daxing City in the Sui Dynasty and the construction period in the Tang Dynasty. The remaining boundary features could not be fully presented, and they were distributed in the Tang City Wall Ruins Park and the city gate in dots and lines. The southern and middle sections of the city wall on the west side of Chang'an city in the Sui and Tang Dynasties have clear remains of the city wall, which overlap with the Tang City Wall Relics Park (West High-tech Section) and Peony Garden, respectively, the southern section of the city wall has several intermittent remains, but the current status is unclear. At present, only a small part of the east section of the city wall is planned to be built as the Tang City Wall Relics Park (Qujiang New Section); the north side of the city wall is mainly the city wall of the Daming Palace Palace City, which has been displayed and utilised in the Daming Palace National Archaeological Site Park. The boundary of Chang'an city from the Five Dynasties to the Yuan Dynasty includes the main urban area in the Tang Dynasty and Chang'an County and Xianning County outside the city (these two counties have no historical elements). Formed, so the wall

boundaries of this period only reflect the characteristics of the west and south sides. The existing remains of Xi'an City in the Ming and Qing Dynasties are in the form of city walls and city gates, and part of the city walls on the west and south sides of the inner imperial city are superimposed under the city walls of the Ming Dynasty and are currently part of the Ring Park as shown in table 6.

Table 7. Statistical table of overlapping lengths of heritage parks and historical boundary elements.

Historical Boundary Elements	Heritage Park Name	Overlap with historical boundary features Total length (m)
City Wall at the Southwest Corner of Han Chang'an City	Han Chang'an City Wall	4305
The city wall and moat at the southeast corner of Chang'an City in the Han Dynasty	Hancheng Lake Park	6270
Daming Palace Wall in Chang'an City, Tang Dynasty	Daming Palace National Archaeological Park	5000
Part of the west wall of Chang'an City in the Tang Dynasty	Peony Garden	1400
Part of the west wall of Chang'an City in the Tang Dynasty	Tang City Wall Ruins Park (West High-tech Section)	3500
South and East Walls of Chang'an City in Tang Dynasty	Tang City Wall Ruins Park (Qujiang New Section)	3293
Xi'an City Wall	Ring City Park	13700

As shown in table 7 shows the overlapping length of each historical relic element and the heritage park. There are 7 parks that are consistent with the shape of the boundary elements, all of which are belt-shaped green spaces, and their total length is about 37468m, accounting for 49% of the total length of the historical boundary elements [40]. However, combined with the actual situation, there are faults in the preservation of the boundary. In the future, Xi'an can continue to build a belt-shaped historical and cultural green corridor relying on the relics or historical locations of the city walls of Han Chang'an and Tang Chang'an, so that the boundary elements can form a continuous form at the urban space level, and then protect and continue the complete outline of the ancient capital of Xi'an.

3.3.2 Element analysis of historical city center

As shown in figure 8 and table 8, the existing forms of the central elements of Han Chang'an City are Weiyang Palace Site, Jianzhang Palace Site, and Changle Palace Site. Weiyang Palace is in the centre, and Jianzhang Palace and Changle Palace are located on both sides, respectively, which can determine the central position of Weiyang Palace. The central elements of the Sui and Tang Dynasties urban context space in Chang'an are Taiji Palace, Daming Palace, and Xingqing Palace. Among them, Taiji Palace and the palace city where it is located are no longer defined by historical relics. Daming Palace and Xingqing Palace can be defined by their own historical relics. Defined, their current form of remains is a heritage park. From the Five Dynasties to the Yuan Dynasty, due to special social reasons, there are almost no remaining spatial elements. The elements of the city centre in the Ming and Qing Dynasties can be determined by the heritages of the Qin City Wall and the four main streets located on the axis. The four main streets are East Street, West Street, South Street, and North Street.

Table 8. Remains of the city center in different periods. (Source: drawn by the authors)

Time	Historical Components	Existing Heritage Status
Han Dynasty	Weiyang Palace, Jianzhang Palace, Changle Palace	Weiyang Palace Ruins, Jianzhang Palace Ruins, Changle Palace Ruins
Sui and Tang Dynasties	Tai Chi Palace, Daming Palace, Xingqing Palace	Daming Palace Ruins, Xingqing Palace Ruins
Five Dynasties to Yuan Dynasty	local government office	feature disappears
Ming and Qing Dynasties	Prince Qin's Mansion	Qin Palace Ruins

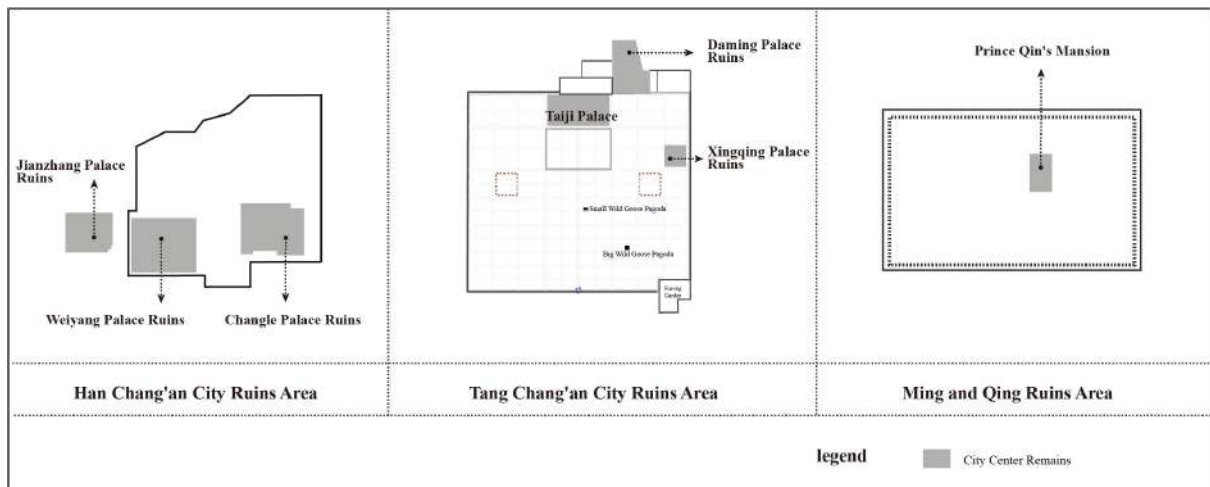


Figure 8. Analysis of the elements of the city center in Xi'an in various historical periods. (Source: drawn by the authors)

3.3.3 Element analysis of historical city axis

The axis of the city is the product of social politics and cultural ideology. In ancient China, the axis of the city often showed a pattern of "long from north to south and short from east to west" to express respect for heaven and adherence to social order. The axis in ancient China was very important in urban planning [28]. In ancient Rome and ancient Greece, the axis of the city was often connected with important public buildings, such as temples and parliaments, reflecting the importance of civil society [8]. The axis itself is not a physical element. Its generation and development must be combined with the roads or important nodes of the city. Generally, some important palaces and ritual buildings will be set up on both sides of the axis, and a certain sequence will be formed through several node elements to strengthen the presence of the axis in the city.

Combined with historical maps and related materials, there are five historical axes elements in each historical stage of Xi'an. The main historical axes are the Han Chang'an city axis, Sui Daxing city axis, Tang Chang'an city axis, and Ming and Qing Xi'an city cross axes as shown in figure 9.

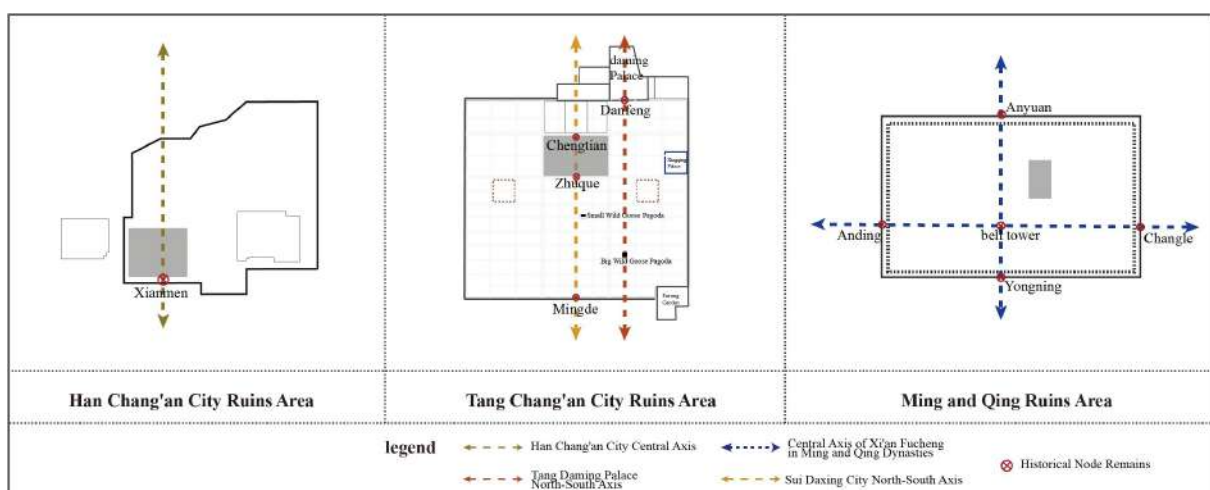


Figure 9. The analysis of the urban axis elements of Xi'an in various historical periods. (Source: drawn by the authors)

From the analysis results in table 9, the central axis of Han Chang'an City is composed of Hengmen, Huayang Street, Weiyang Palace Front Hall, and Xi'an Gate. The only remaining Hengmen Ruins, Weiyang Palace Front Hall Ruins, and Xi'an Gate Ruins are all included in the Hancheng Lake Heritage Park, without highlighting the order of the axis.

The historical constituent elements of the north-south central axis of Sui Daxing City are Chengtian Gate, Suzaku Gate, and Mingde Gate. Among them, the Chengtianmen site is in today's Lianhu Park, the Zhuquemen site overlaps with the Zhuquemen in Huancheng Park, and the Mingdemen site park was built based on the Mingdemen site.

The historical components of the Tang Chang'an city axis is Daming Palace, Danfeng Gate, and Big Wild Goose Pagoda. The existing heritages are in the Daming Palace National Heritage Park, and the Big Wild Goose Pagoda is in the Daci'en Temple Ruins Park.

The city axis of Xi'an in the Ming and Qing Dynasties consisted of two lines: Anyuan Gate, Bell Tower, and Yongning Gate from north to south. Andingmen, Bell Tower, and Changle Gate from east to west. The bell tower is the intersection centre of the two axes. Now the bell tower square has been built. The streets formed by the connection of the other four nodes form four avenues in the south, east, north, and west, with the bell tower as the intersection. The four city gates are also included in the ring park.

Table 9. Remains on the city axis in different periods. (Source: drawn by the authors)

Time	Historical Components	Existing Heritage Status	Heritage Park
Han Dynasty	Hengmen, Huayang Street, Weiyang Palace Front Hall, Xi'an Gate	Hengmen Ruins, Weiyang Palace Front Hall Ruins, Xi'an Gate Ruins	Hancheng Lake Relics Park
Sui Daxing City Axis	Chengtian Gate, Suzaku Gate, Mingde Gate	Chengtianmen Ruins, Zhuquemen Ruins, Mingdemen Ruins	Mingdemen Ruins Park, Lianhu Park, Ring City garden
Tang Chang'an City Axis	Daming Palace, Danfeng Gate, Big Wild Goose Pagoda	Daming Palace Ruins, Big Wild Goose Pagoda	Daming Palace National Archaeological Site Park, Tang Daci Ensi Ruins Park
Ming and Qing Dynasties	Anyuan Gate, Yongning Gate, Anding Gate, Changle Gate	bell tower West Street and East Street. South Street and North Street	Ring Park

3.4. Spatial analysis, relic location of urban heritage.

In this study, the analysis value of the integration degree of the whole play is selected, and the result of space syntax analysis is shown in the figure 10. Import the analysis result data into excel for data analysis. The traffic accessibility of the roads around urban sites such as Beilin District, Lianhu District, and Xincheng District is good. The spatial distribution of the main road network with strong identification has a high degree of matching, which also enhances the convenience of transportation to these urban heritages. The accessibility of road traffic in peripheral spaces such as Weiyang District, Chang'an District, and Baqiao District is relatively poor. This also confirms that, with the pressure of urbanization, the urban sites located in the historical core area have not lost their core status with the expansion of urbanization space.

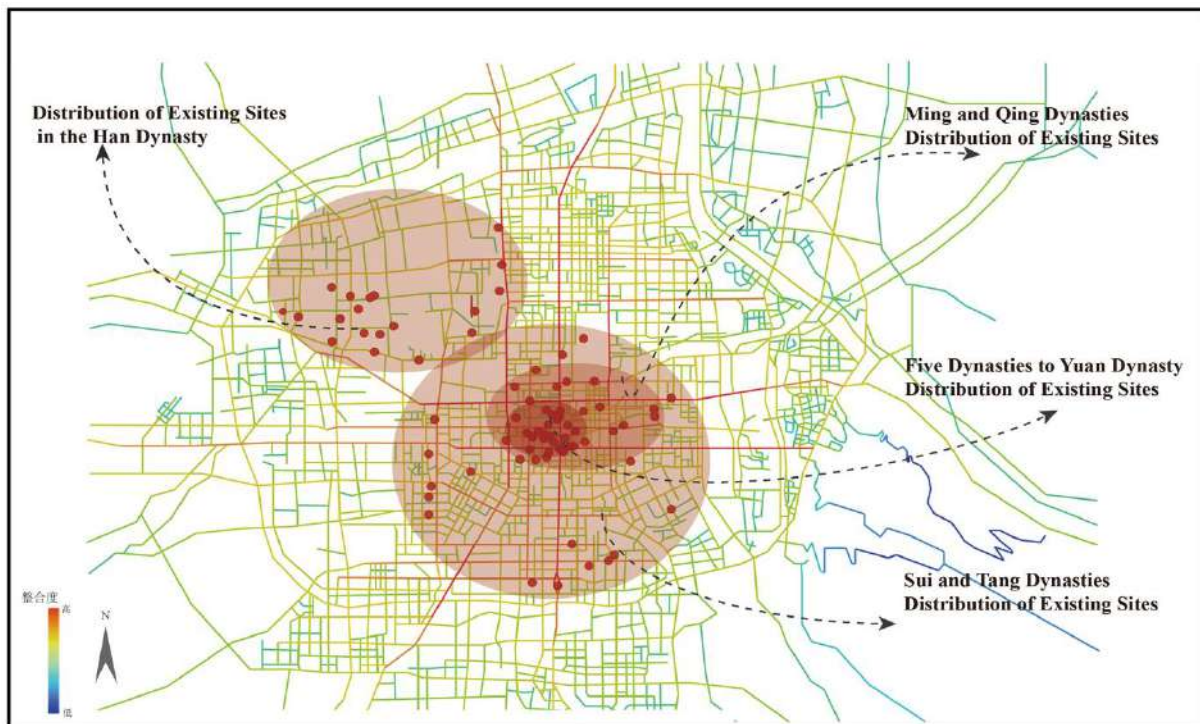


Figure 10. Road accessibility analysis map of Xi'an urban area. (Source: drawn by the authors)

4. Discussion

4.1. Research findings

First, in the development process of Xi'an city, we can see the embodiment of this complexity. In each historical period, whether it is government administration, military defence, commercial transactions, or the distribution and adjustment of various functional heritages such as residents' residences and religious sacrifices, they are all preserved and displayed in specific forms. Most of these heritages are displayed in the form of heritage parks and commercial activities, which not only reflect the protection strategy of urban heritage but also provide a way of sustainable use. As Smith (2006) said, the protection and utilisation of urban heritage should be an inclusive and pluralistic process, and the form of heritage parks and commercial activities provides an effective way to practise this.

In addition, the change of city boundaries, centres, and axis in various historical periods is an important topic of this research. The core elements of these cities and their remains are protected and utilised in the form of heritage parks. Through the in-depth study of these elements, we can see the historical continuity and the change of time in the urban space. This continuity and change not only reflect the historicity of the city but also its vitality. Cities should not only respect and protect history but also adapt to the changes and developments of the times. Only in this way can the protection and utilisation of urban heritage be truly sustainable.

Finally, the current urban road system is deeply analysed using the method of space syntax. The results show that the distribution of heritages are concentrated in the section with a high concentration of cities. This demonstrates the key role of historical monuments in shaping the spatial structure of modern cities. Hillier (1996), in his work "Space is a Machine: A Theory of Architectural Configuration", emphasised the important influence of the structure and organisation of urban space on urban functions and activities. Our findings are consistent with Hillier's point of view.

4.2. Limitations

In the research, due to the huge number of heritages, there are statistical errors in the classification and summary of urban heritages. When analyzing with the space syntax line segment model, due to the huge number of line segments and the complexity of the line segment model, there will be small errors in the analysis.

5. Conclusions

In the study of the sustainable development of urban heritage, the influence of the distribution of urban heritage on the urban pattern is a major research field. For the ancient city of Xi'an, we found that the evolution of the city is a complex process through in-depth research on its historical evolution process and urban form changes, which includes not only the overlapping of history, but also the constant adjustment and reshaping of the spatial layout of various functional heritages. Jacobs (1961) emphasized the diversity and complexity of urban development. He believes that the form and function of the city is not a simple linear development, but the overlapping and interweaving of multiple spaces and functions.

The study found that the distribution of urban heritage has an important impact on the formation and evolution of urban patterns. The city's historical relics are protected and displayed in the form of heritage parks and commercial activities, which not only reflects the protection strategy of urban heritage, but also provides a way of sustainable use. The influence of historical relics on modern urban space reflects the dialogue and interaction between history and modernity in urban space. Through in-depth research on the protection and utilization of urban heritage, we can better understand and guide the development of cities, so that the protection and utilization of urban heritage can truly achieve sustainability.

Under the pressure of urbanization, urban heritage has not disappeared, but has been integrated into urban development in new forms. More importantly, they have not lost their core status, but have become an important part of the urban spatial layout, thereby further strengthening the city's historical characteristics and cultural connotations. This phenomenon not only reflects the city's respect and protection of historical heritage, but also reflects the important contribution of historical heritage to urban development. Therefore, we believe that the protection and utilization of urban heritage should be included in the important agenda of urban planning and development, to achieve the sustainable development of urban heritage.

In conclusion, this study systematically expounds whether the spatial characteristics of urban heritage lose their core status with the process of urbanization from the perspectives of functional complexity, spatial continuity, and space syntax. Through such research, not only can the value of urban heritage be better understood, but also sustainable development experiences can be identified.

The findings of this research have far-reaching implications for heritage conservation, urban planning, and policymaking. First of all, by conducting an in-depth excavation of the historical context of urban heritage, it can provide a more comprehensive basis for the protection of historical and cultural heritage, so as to formulate more effective protection measures, vigorously protect the precious wealth left by history, establish a network of urban heritage sites, and make the faulty cities sites incorporated into the network planning are conducive to the evaluation and planning of the entire urban site. Secondly, we should strengthen the construction and management of the surrounding environment of urban heritage, improve its accessibility and continuity, and make it better integrated into urban public space and a part of urban life. Comprehensive research on the spatial characteristics of urban heritage can help guide urban planning, integrate historical heritage with modern urban functions, achieve sustainable urban development, integrate social activities of urban heritage into public space, and shorten the distance between people and heritage, forming the city's self-identity and cultural self-confidence. Finally, the results of this study provide an important reference for policymakers to find the best policy path between balancing the urbanisation process and the protection of historical heritage, to create a benchmark for Xi'an's urban pattern, to continue the historical context, and to ensure the continuation of its historical coordinates.

In the future, combining Xi'an's unique history and culture with the HUL (Historic Urban Landscape) method proposed by UNESCO to formulate future sustainable development plans will be of guiding significance for the formulation and promotion of future policies, and then the research on urban heritage will study urban heritage in the context of cities, use space syntax to build urban heritage networks in the context of space networks, link the number of urban heritage sites to line segment models, and do further research for the sustainable development of urban heritage.

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