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Transition of Urban Morphology in the Mountainous Areas Since Early-Modern Times from the Perspective of Urban Historic Landscape—A GIS Tools and Historical Map Translation Approach

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Abstract: Regenerating cities must blend modernization and heritage. Both urban morphology and Historic Urban Landscape (HUL) highlight historical processes and may assist in regeneration. Using Chongqing as the study example may further understand mountain cities, which are prevalent worldwide but seldom examined in morphology research. This study explores and organizes the historical modernization of Chongqing's parent city from early-modern times to the present day using a universal approach established in this research developed by the HUL perspective and research framework, Geographic information system (GIS), Depthmap tool, and historical map translation method. Large-scale modernization occurred prior to the 1980s, followed by more modest rehabilitation projects. The whole procedure is described by the phrase "Construction first, then planning, then transformation," which entails a "free growth" block structure at the outset, along with planning control. The study contributes the following: (1) Establishing a theoretical framework and research technique for the universal city based on historical sources and modern instruments; (2) Chongqing's future sustainable development and historical preservation depend in large part on figuring out the city's complicated modernization history; (3) The study of mountain cities may benefit from understanding the geographical development and spatial dynamic layering of Chongqing. (4) This study bridges the gap in time by going beyond the early modern period covered by the previous ones and into the post-statehood era (1949–2022).

Keywords: urban morphology; spatial dynamic layering; GIS; historical map translation; sustainable development; historical preservation; mountain city

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1. Introduction

Nearly all Chinese cities now have advanced from the stage of incremental development to the stage of stock regeneration [1]. The fundamental difficulty at this point is striking a balance between modernity and conventional urban patterns [2], and historic preservation is becoming a common element of urban planning and is seen as one of the major forces for revival [3]. Many scholars have studied urban change from the perspective of urban morphology [4–7], which emerged in the early 19th century, and three main schools of thought were formed: the Cozen historical–geographical school [4], the Muratori–Caniggia typological school [8], and the Versailles historic school [9]. All three viewpoints are based on old maps and materials, emphasizing the logic of urban composition [10], and advocate a historic evolutionary perspective to understand the city [11], despite the differences in their approaches. The Historic Urban Landscape (HUL) perspective and approach were verified to be an optimum ideology [12], which sees the city as the product of the interaction between the natural environment and human traditions accumulated over time [13], helping protect heritage areas in more sustainable ways [14]. On a theoretical level, two theories can serve as a guide for urban regeneration activity and sustainable development [15].

The historical process of urban modernization in China started around the late Qing Dynasty (the late 20th century) and is characterized as complex, dynamic, and non-uniform [16]. Sorting out the process is especially crucial during the period of urban regeneration [1]. Most of the materials that exist to record urban changes are historical documents and maps, which are essential to the historical study and reconstruction of the rural landscape [17]. Urban development now requires the use of cutting-edge research, technology, and tools to combine the database of historical urban geographic information [18].

The mountainous environment is widely spread in the world, where twenty-six percent of the world's population lives and covers twenty-five percent of the global land area [19]. Mountainous cities with undulating topography and complicated road networks offer an urban environment distinct from that of plain places [20]. There is some research on mountain cities that addresses spatial morphology and historical development, with the majority concentrating on ecology [21,22], geography [23], transportation [24], etc.

Chongqing, in southwest China, is a typical mountain city and has developed into a crucial hub city due to its advantageous position. Situated at the confluence of the Yangtze and Jialing rivers, Chongqing City has been an important town in eastern Sichuan since ancient times [25]. Most studies on Chongqing's cities concentrate on the macro and regional levels [26] and the technical elements of environmental ecology [27], with little research looking at meso and micro spatial patterns. Taking Chongqing as a study case can contribute to spatial morphology evolution research and the study of mountain cities.

This study aims to provide a historical-level theoretical foundation and research methodology for the universal city during the stock regeneration stage. With this aim, this paper creates an integrated city history map as a basis for historical research, and the city history map contains information over time, from the late 19 century to now, based on historical maps and documents [28]. Then, this paper establishes a set of urban historical transformation research approaches and frameworks from the perspective of HUL and urban morphology, using historical materials as research materials and cutting-edge technology to examine how urban morphology has changed through the case study of Chongqing.

Additionally, the majority of studies on this topic focus on the modern era (the late 20th century–1948). During this period, China has undergone a huge modern transformation. Modernization is complex, dynamic, and non-uniform and a hot topic in Sinology [16], so a large number of scholars have studied this period, and few focus on the post-statehood era (1949–2022). However, the time frame of this paper is from early-modern times to the present, bridging the gap in the study of Chongqing's urban morphology changes since 1949 in terms of time scale.

2. Materials and Methods

2.1. Historical Urban Landscape Perspective and Research Framework

A city's internal growth of its physical shape is the result of social, cultural, and other factors operating together, according to urban morphology, which emphasizes that the city is a combination of natural geography and artificial environment and that its development is a dynamic and continuous process [29–31]. Based on this, the intangible aspects of the urban landscape (which includes the natural and cultural as well as the physical and intangible) are given special consideration in the field of the urban historical landscape. Therefore, learning about the city from the perspective of the historic urban landscape is an essential first step.

The creation of a general- suitable framework (Figure 1) for the investigation of historic urban landscapes is attempted. Each urban component is interdependent on the others; thus, it is important to include the macro-regional, meso-city, and micro-block levels as part of the study context, and the linked contextual combination is the basis for conducting the study. It is, on the one hand, the physical of the city. Conzen's framework of townscape study begins with three aspects—pattern of plan, land use, and building

forms—but the plan pattern is the most conservative morphological complex since it has remained relatively unchanged throughout the city's history. In order to study and explain the formation process of the plan pattern, a historical evolutionary perspective is used, and the elements of the plan are broken down into street and street-system, plots and street-block, and block-plan [29]. Street is the skeleton of the plan, its geometry and topological structure are the elements studied, and the street lines divide the street-blocks, each containing a series of property plots, the shape, and organization of which reflect the geographical variation. Block-plan refers to the area occupied by the building, and its shape and relationship to the plot are elements of the study (Figure 1). On the other hand, the perceptible space of the city highlights the subjective cognitive and perceptual side and can be studied through literature, images, and research materials from various time periods in order to analyze the public perception and supplement the daily life and invisible side of the city from an empirical vantage point [32,33].

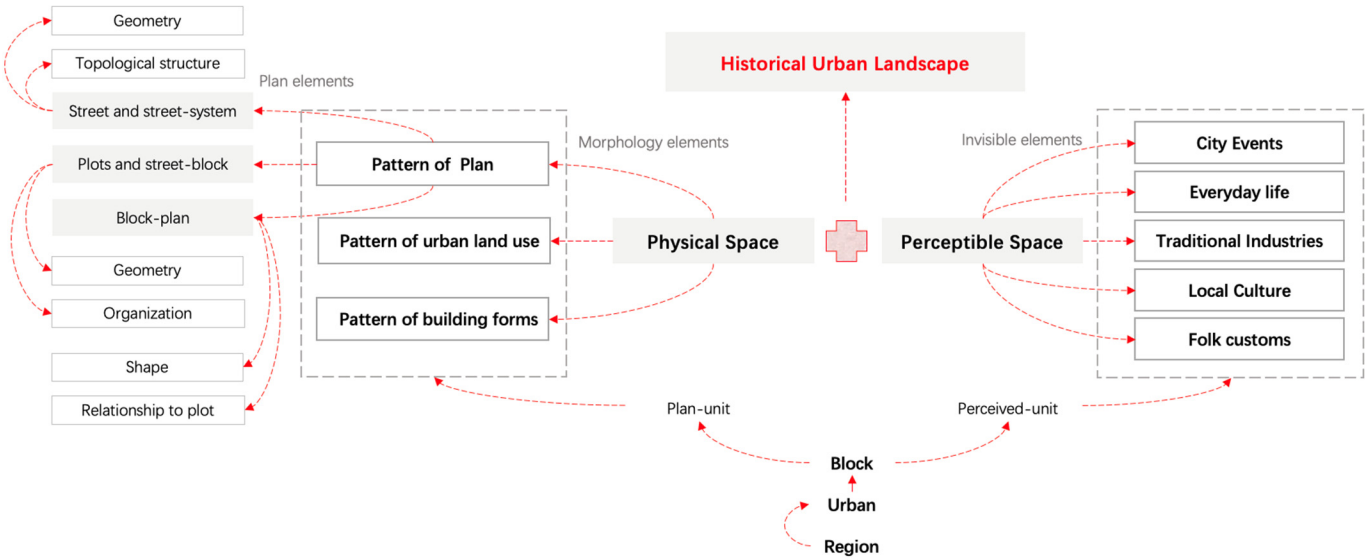


Figure 1. A general-suitable framework for the investigation. (Source: own study).

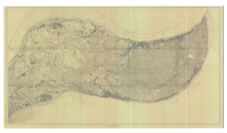
2.2. Historical Map Translation Method and Integrated City History Maps

For studies of urban evolution, particularly the city plan portion in the framework above, historical maps are a crucial source of information. City plans are a picture of the historical landscape's layers and are a goldmine of historical data.

This investigation spans the period between the late Qing Dynasty (the late 20th century) and the current day, and it includes maps of cities created before the formation of the People's Republic of China. Inaccuracies in cross-temporal spatial comparisons are inevitable due to the fact that the available historical maps were mostly created in a measured way, creating a gap between the precision of geographical position and the accuracy of contemporary maps. In order to visually portray the information of the current city on modern maps [28], it is important to utilize the historical map translation technique to convert the early historical maps into integrated history maps of the city using modern maps as the map foundation.

The four processes that make up the historical map translation method are the basic divisions. The selection of historical maps is the first stage. These historical maps may be categorized into three groups based on their use: mapping maps, thematic maps, and planning maps. Table 1 displays the ten typical maps that have been chosen. Most of the time, the other two types of maps are used as supplementary reference materials, but mapping maps, which contain rich geographical elements such as topography, water systems, and man-made features such as buildings and roads, are the most important materials for historical map translation work [34,35].

Table 1. Modern Historical Mapping, Thematic Maps and Planning Maps of Chongqing (Source: Historic maps, The historical atlas of Chongqing).

Name	A Full Map of Chongqing's Geography	New Measurement of Chongqing City Full Map	Topographical Map of Chongqing	Chongqing Street Map	Chongqing City Street Detail Map
Year	1900	1925	1929	1937	1945
Type	Mapping map	Mapping map	Mapping map	Mapping map	Mapping map
Information	Circumvallation, streets, street outlines, etc.	Circumvallation, streets, street outlines, etc.	Circumvallation, streets, street outlines, terrain	Circumvallation, streets, street outlines, road level	Circumvallation, streets, road level, etc.
Preview					
Name	Chongqing street map	Road network map	Land use map	Population distribution map	General traffic planning map
Year	1946	1946	1946	1946	1946
Type	Mapping map	Thematic map	Thematic map	Planning map	Planning map
Information	Circumvallation, streets, some block-plans, etc.	For road level research	For land use research	For population distribution research	For traffic planning research
Preview					

The second step is extracting, filtering, and classifying map information's constituent parts. The informational components on the historical map must first be removed. Because of the urban morphology and traffic network involved in this research, the retrieved components must be inspected and categorized. However, certain thematic maps may also give information on population distribution and land use, and it excels at obtaining aspects of quantitative categories such as perimeter and side lengths.

The third step is using Arcgis to align, locate, and overlay the fixed components as the reference coordinate system. The study components are placed and overlaid on the maps using the fixed elements as spatial reference coordinates, and the historical maps are aligned with the contemporary satellite maps using Arcgis. A basic direction in terms of area, time, and information should be present throughout the translation process. Translating the main streets, waterways, and other elements based on the city gates and walls is a good example of setting the big spatial pattern before refining others; translating maps not drawn with modern technology is a good example of restoring maps closer to the present time first [28].

Using the 1940s Yuzhong District map as an example, fixed elements were identified from a modern satellite map and used as control points; existing city gates and landmarks were then used as precise reference coordinates; these eight coordinates (Table 2) were comprised of the locations of the four city gates (Dongshui, Taiping, Renhe, and Tongyuan) and four landmarks (Jiaochangkou, Monument to the people's Liberation Xiaoshizi, and Bashu Secondary School). The current satellite image of Chongqing City from Google Earth and the 1946 Chongqing City Street Map were imported into Arcgis. Using the "Geographic Alignment" toolbar and the current satellite map as the base map, the eight control points on the 1946 Chongqing City Street Map and the current satellite map were clicked one by one until they were aligned. The information on the same historical stage is then translated into this map (Figure 2).

Table 2. Eight precise reference coordinates (Source: Google Earth).

Reference Coordinate	Dongshui Gate	Taiping Gate	Renhe Gate	Tongyuan Gate	Jiaochangkou	Monument to the People's Liberation	Xiaoshizi	Bashu Secondary School
Longitude	106.594311	106.589156	106.586298	106.573766	106.58056	106.583541	106.589954	106.568528
Latitude	29.565065	29.558876	29.556701	29.561748	29.558926	29.563475	29.566232	29.568175

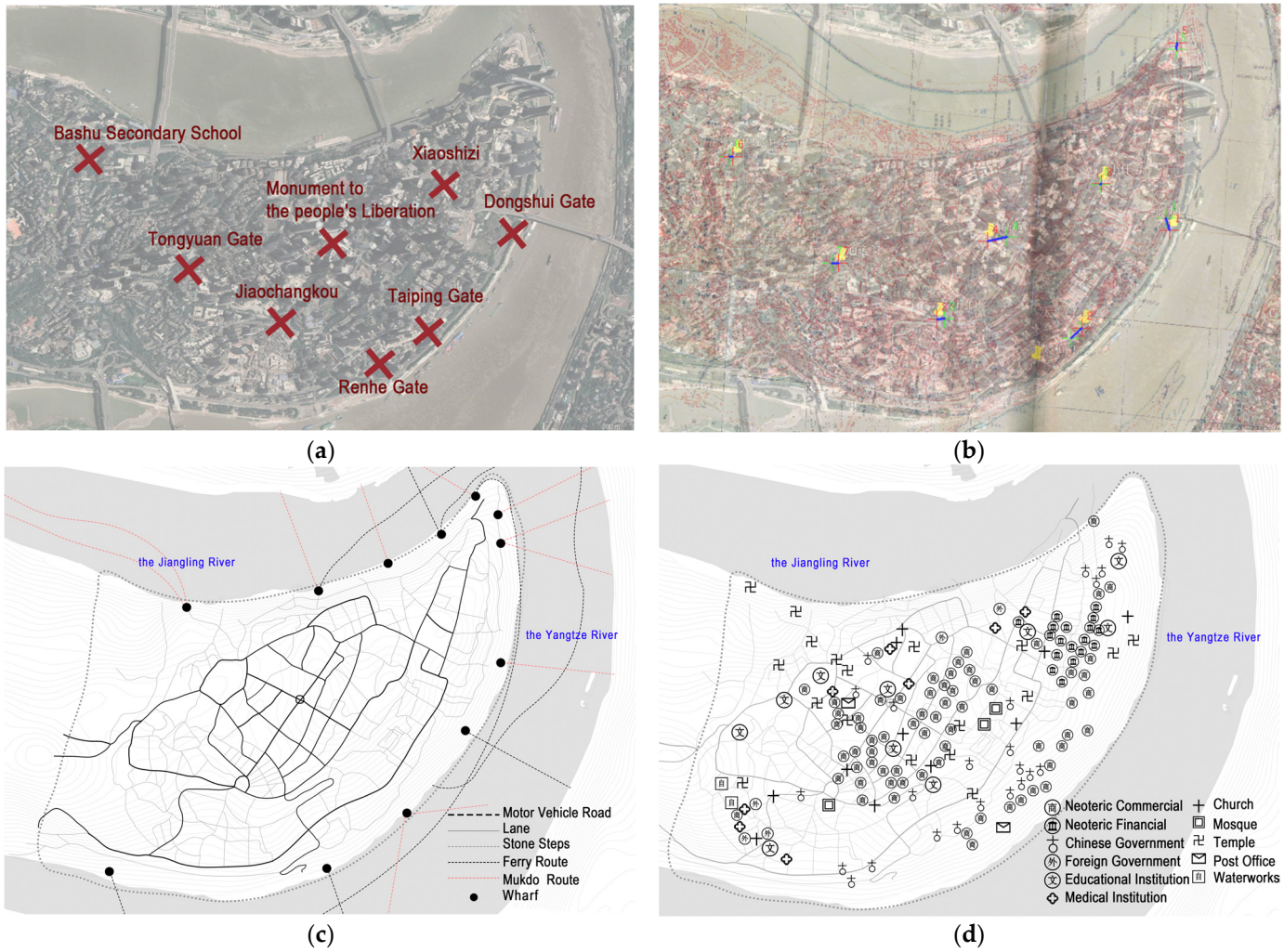


Figure 2. (**a**) Reference coordinate in Google Earth satellite map; (**b**) Geographic alignment in Arcgis; (**c**)Translated map-Transportation situation in the 1940s; (**d**)Translated map-Important buildings distribution situation in the 1940s. (Source: Arcgis Screenshot, historical maps).

In the final step, errors are corrected using documentary sources. There is a need for further geographical correction of the spatial information retrieved from the historical map, and this correction is mostly based on textual information [28]; the majority of this textual information is sourced from local records and other authentic historical sources. It takes time to translate historical maps, and the newly created urban historical maps must be continually improved.

2.3. Gis and Depthmapx Tool

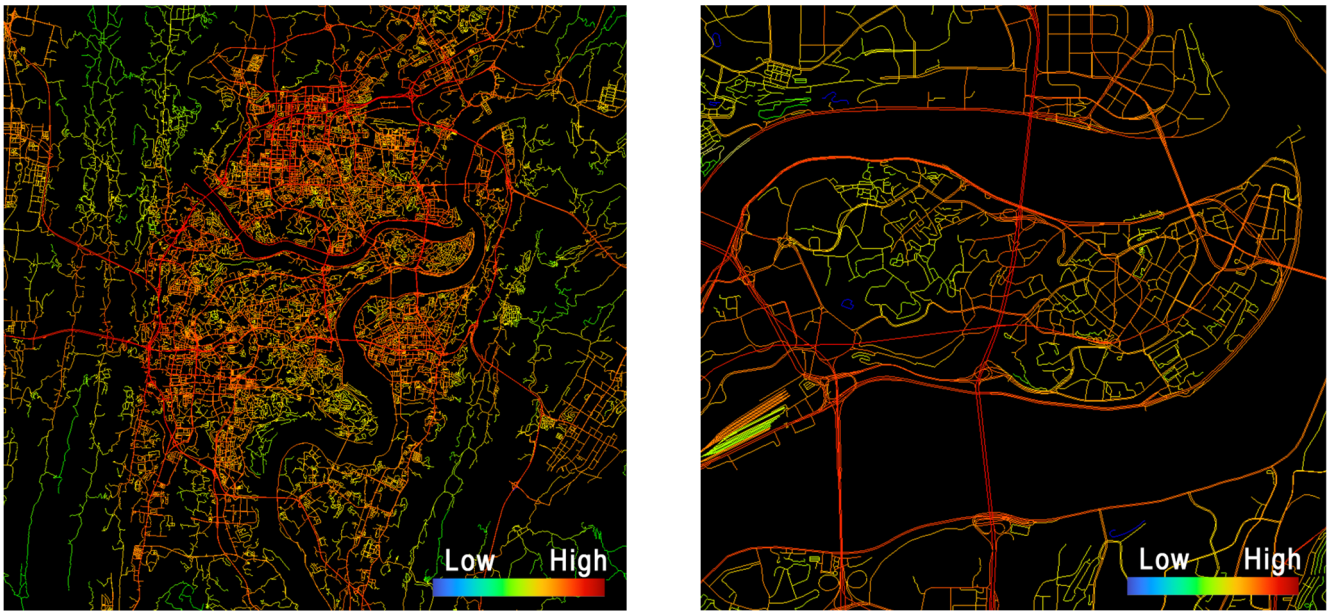
In general studies of historic urban landscapes, qualitative descriptions are used to draw conclusions. However, urban landscape research using only qualitative methods, to an extent, is not convincing, and scientific research must be used to summarize the

development of things from quantitative data. Qualitative methods are used to describe the city at a macro level, while quantitative methods are typically employed at a more micro level, such as street length and width shape, street frontage height, building density, volume ratio, etc. [36,37].

Urban spatial quantitative indicators may be broken down into many different types, including those that are morphological, dense, functional, etc. [38]. Quantitative index systems may be useful research tools and methods, but they need to be tailored to the specific aims and goals of each study. Focusing on urban transportation networks and plan spatial morphology, this analysis breaks down urban morphology into geometric, topological, and functional indexes, which are then applied to the two subsets of urban morphology, lines, and surfaces [39].

GIS can analyze geometric parameters, which are used to describe the geometric form of the material, such as the perimeter, average height, shape index, number, density, etc. of buildings, or the length, width, and density of roads, sidewalks, bike lanes, and other types of infrastructure. ArcGIS is used to collect geospatial information from the internet, process it, and display the results graphically [40–42].

The DepthmapX tool can analyze topological structure (Figure 3), which ignores the particular physical spatial scale and emphasizes the structural relationship of space, such as the degree of integration and choice in the spatial syntax; functional parameters are used to express the land use and functional distribution, which can express the spatial vitality at the level of social activities and complement the singularity of the aforementioned material scale [43,44]. They consist of functional density, functional mixture, and the kind of land parcels.



(**a**) (**b**)

Figure 3. (**a**) Integration of Chongqing's main city; (**b**) Integration of Chongqing's parent city. Chongqing's parent city refers to the Yuzhong Peninsula, a region with a long history as a political, cultural, and economic center. (Source: DepthmapX Screenshot).

The variability of the research materials should be taken into consideration while conducting ephemeral investigations. Since the research materials are based on current maps, it is challenging to obtain both functional class parameters and density-related indicators in geometric parameters in the early-modern literature. Many data were unavailable before the development of contemporary scientific and technological methodologies.

3. Overview of the Built-Up Area of Chongqing's Main City's Spatial Changes

3.1. High-Speed Traffic and Increased Road Density

The movement of people and things that require transport between and within the cities of Chongqing has risen more often as a result of modernization and urbanization, which is a sign of increasing mobility [45,46]. A city cannot grow in size without its dynamic component, which is traffic [47]. Since early-modern times, the transportation system—which is the carrier of material flow—has seen drastic changes in terms of transportation technology, methods, and network. After the liberation, the waterway-based transportation situation from the early stages of the country's founding was gradually changed, and after strengthening the construction of highways and railroads, the connection between Chongqing and the neighboring cities was gradually tightened (Figure 4), all in keeping with the general trend of the evolution of the city's external transportation.

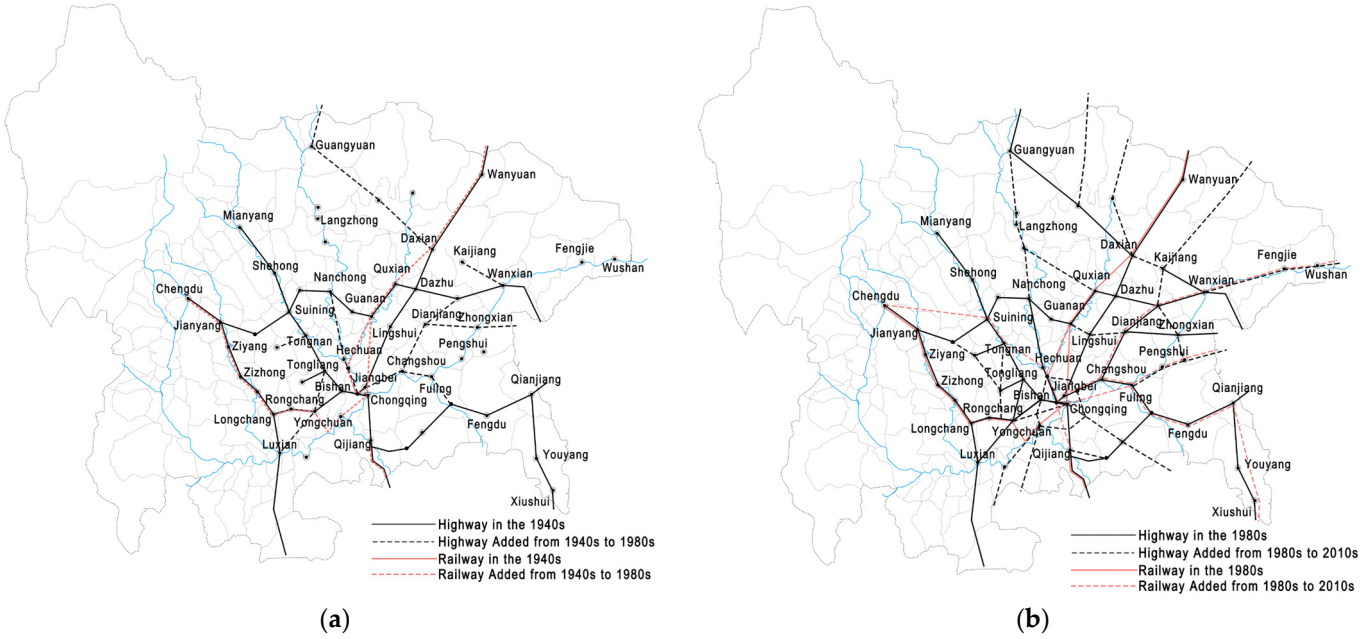


Figure 4. (**a**) The evolution of transportation between Chongqing and the surrounding cities from 1940s to1980s; (**b**) The evolution of transportation between Chongqing and the surrounding cities from 1980s to 2010s; (Source: Historical maps, Chongqingshizhi, Google Earth, etc.).

Urban traffic has risen in volume as a result of modernity, population growth, economic development, and the concentration of a large number of people and cars inside the city, while urban sprawl has increased the distances people must travel to go anywhere in the city. Changes in intra-city transportation modes and technologies have resulted from rising intra-city mobility, while the intra-city transportation network system has evolved to meet the demands of urbanization in terms of land use, traffic, and other factors [48]. The expansion of new urban paths that new modes of transportation rely on, such as the construction of high-capacity, quick, and efficient railways and elevated railways to address the issue of high hills and steep slopes in Chongqing (Table 3), can be summed up as the first change in the urban transportation network. The second change is the continuous widening of inner-city roads and the growing density of the population. The complexity of the transportation system has increased as a result of the diversity of traffic; therefore, the organization of urban transportation is more three-dimensional and systematic [49].

Table 3. Development of subway in Chongqing (Source: the National Bureau of Statistics, Chongqing Shizhongquzhi).

Year	2006	2007	2008	2009	2010	2011	2012
Passenger volume	2.002×10^7	3.347×10^7	3.988×10^7	4.181×10^7	4.576×10^7	8.332×10^7	2.4363×10^8
Operating mileage/km	17	17	17	19	17	70	131
Number of vehicles	52	60	60	84	108	296	558
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Passenger volume	4.0049×10^8	5.1710×10^8	6.3247×10^8	6.9343×10^8	7.4310×10^8	8.5787×10^8	1.04187×10^9
Operating mileage/km	170	202	202	213	264	313	329
Number of vehicles	702	888	918	978	1176	1806	2130

Because of its location at the confluence of two major rivers, Chongqing has always relied heavily on the transportation services provided by its ports. After the start of the War, ferries emerged in response to the resulting population boom. Before the 1960s, traveling from one side of the city to the other required using the waterways that crisscrossed it; however, after the construction of bridges over the rivers and cableways to the two rivers, faster and more convenient ways of crossing the rivers emerged, displacing the cross-river routes and, later, the more heavily trafficked downriver routes [50]. The new transportation methods changed the way people traveled around the city, and public water transportation gradually declined (Figure 5).

3.2. Spatial Expansion and Functional Area Transformation

The built-up area of Chongqing's main city has recently shown a tendency for outward growth (Figure 6). Specifically, the data on Chongqing city's outward expansion were slow from 1956 to 1983, which was related to the overall national background of the time, and the growth rate accelerated from 1983 to 1997, which was the expansion of the urban spatial pattern brought about by the accelerated economic development of Chongqing city since the reform and opening up, and the built-up area grew rapidly from 1997 to 2007 (Table 4), and Chongqing as a municipality directly under the Central Government grew rapidly as a result [51]. Chongqing's development focused on the main city at first, and the city expanded to non-main urban areas in the later years, a manifestation of urbanization in the rural areas; this expansion continued in the years 2007–2017, but at a slower rate than in the decade before the direct administration. The city expanded to the west and south in its early years, but after the administration, with better land and greater urban development space reserves, the north became the major direction of urban growth.

Table 4. Change in the built-up area of Chongqing's main city (Source: Chongqing shizhi and the National Bureau of Statistics).

Year	Built-up Area of Chongqing's Main City/km^2	Proportion of Built-up to the Main City	Built-up Area of Chongqing/km^2	The Built-up Area Proportion of the Main City to the City
1952	44.36	15.07%		
1983	84.14	15.10%		
1997	156.20	2.85%	389.8	40.07%
2007	489.90	8.95%	873	56.12%
2017	732.20	13.38%	1573	46.54%

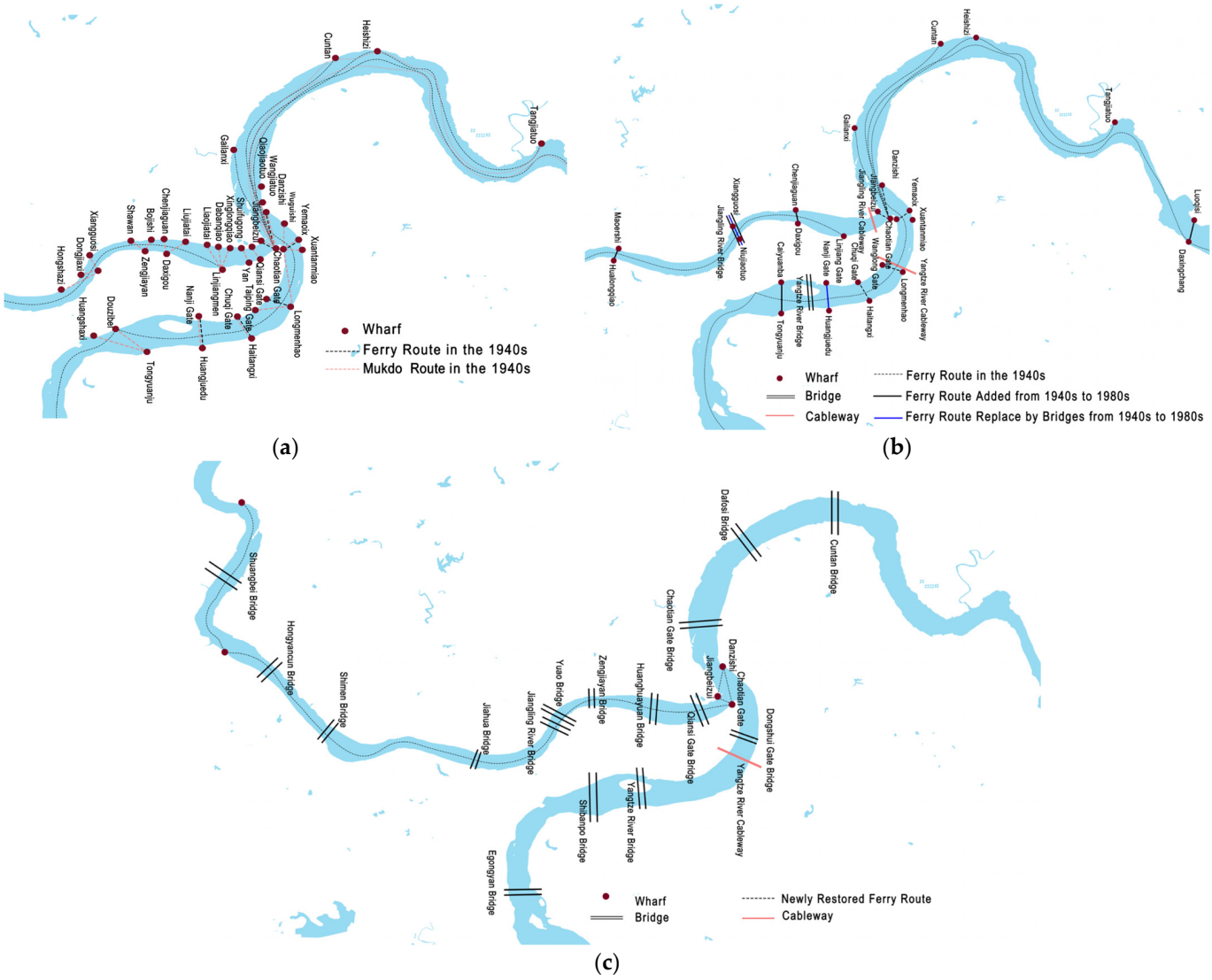


Figure 5. (**a**) Mukdo Routes and Ferry Routes on the Two Rivers in the Early 1940s; (**b**) Changes in the way the main city crossed the River from the 1940s to 1980s; (**c**) The contemporary way to cross the River; (Source: Own study).

As the city grew, the macroscopic land use arrangement changed, which in turn impacted the nature of urban life to some degree. Given the city's geography and traffic patterns before 1949, the city's industrial property was virtually evenly spread on the riverbank terraces. The vast majority of the inwardly relocated factories were constructed with only the water transportation conditions of the Jialing and Yangtze rivers in mind, without a thorough understanding of the conditions in Chongqing, with intertwined factory areas and residential areas, an extremely irrational layout, and an extremely uneven production distribution, with factories, monstrously concentrated on the banks of the river. New industrial zones formed on the south side of the city as the city's scientific progress led to the gradual evacuation of industrial land initially clustered on both sides of the Jialing and Yangtze rivers with an exceedingly inappropriate layout. Since the 1990s, the government has actively promoted and supported large-scale industrial development in order to achieve development goals. This has directly led to the priority growth of industrial land, and it is clear that the new periphery of the city is primarily an industrial zone. The city's infrastructure is progressively becoming more streamlined.

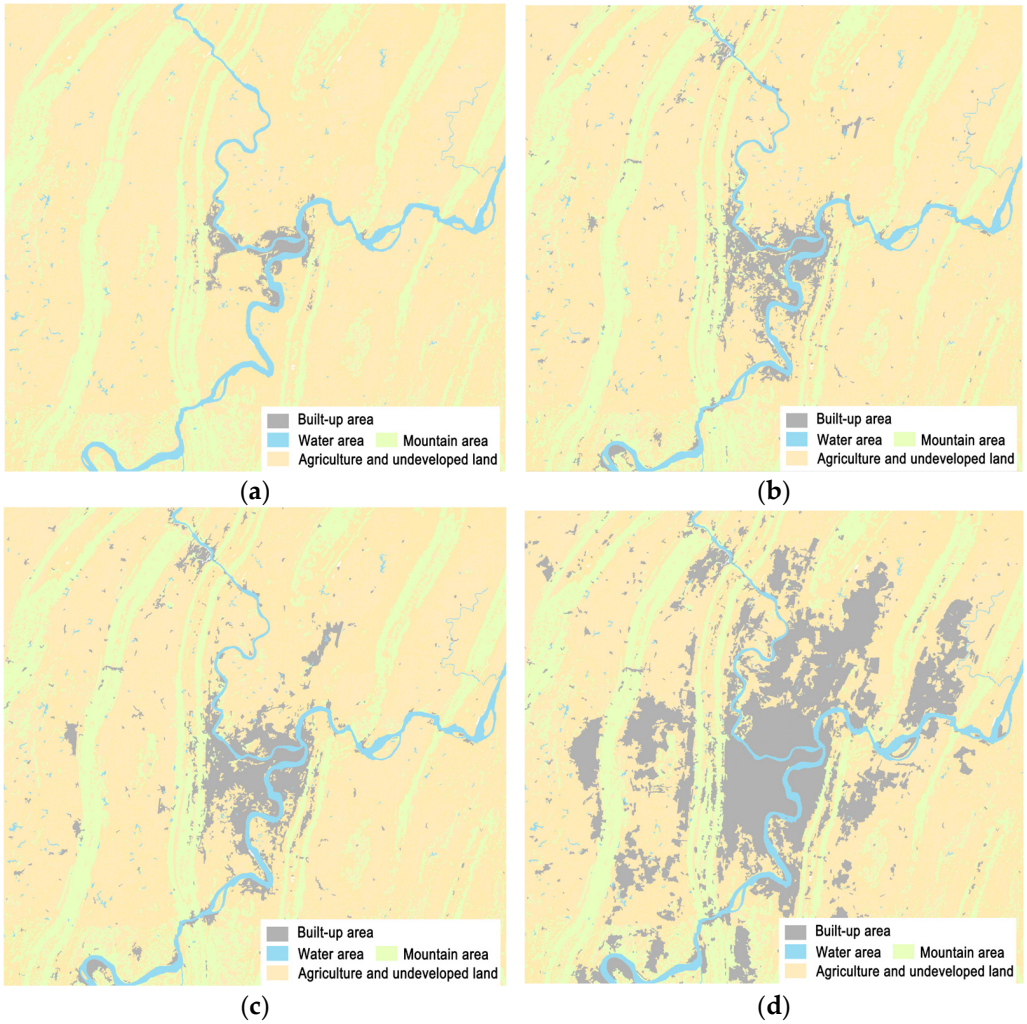


Figure 6. (**a**) The built-up area of Chongqing's main city in the 1940s; (**b**) The built-up area of Chongqing's main city in the 1980s; (**c**) The built-up area of Chongqing's main city in the 2000s; (**d**) The built-up area of Chongqing's main city in the 2010s; (Source: Resources and environment science data center of Chinese Academy of Sciences).

4. Identifying the Spatial "Dynamic Layering" of Chongqing's Parent City

4.1. Modernization of the Transportation Network in the Parent City

Chongqing's ancient Yuzhong Peninsula serves as a case study for this investigation of the city's evolution. Located in the heart of Chongqing city, which has served as a geographic and developmental epicenter at different times since antiquity, the Yuzhong Peninsula is bounded by the Yangtze River to the east and south and the Jialing River to the north. The sample of this investigation is drawn from an area bounded on the west by the Yangtze River Bridge, Shihuang Tunnel, and the Huahuayuan Bridge, and on the east by the Jialing River and the Yangtze River itself. This sample, covering an area of roughly 3.2 square kilometers, represents the oldest and densest part of Chongqing's urban landscape, and the process of change in this region since early-modern times is sorted out so that Chongqing's urban historical landscape may be studied in detail.

More than 240 alleyways and lanes, none wider than eight feet, existed in Chongqing in the early 1920s (Figure 7), and there was not a single road in or around the parent city. Less than 40 km of drivable roads existed in 1949; by the end of the 1980s, that number had increased to 72.84 km (Figure 7), and the overall length, road grade, and construction quality of drivable roads had all been improved [52,53]. With the construction of new roads such as the Jialing River Binjiang Road and the Yangtze River Binjiang Road, the

road network plan pattern of the river section has been altered, and the existing roads such as Minquan Road, Zhongxing Road, and Heping Road have been widened and repaired to become the city's main arteries. Furthermore, the Qiansimen Tunnel, Shihuang Tunnel, and Jiefangbei Underground Ring Road were built to alleviate ground pressure and demonstrate the tunnel's reasonableness as a mode of transportation in the mountain city of Chongqing [54], which is of great significance to the development of urban roads (Figure 7).

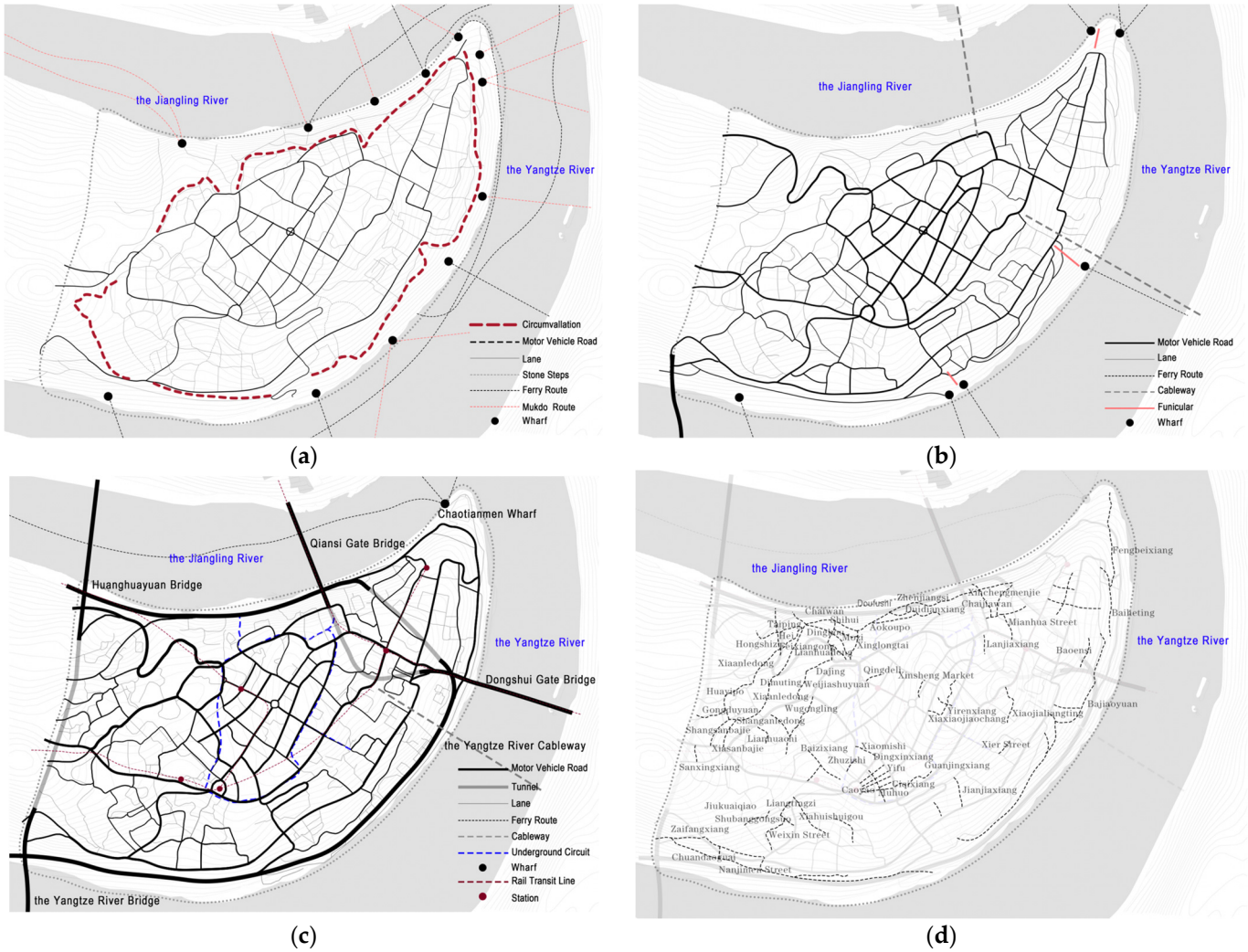


Figure 7. (**a**) Transportation network in the 1940s; (**b**) Transportation network in the 1980s; (**c**) Transportation network in the 2010s; (**d**) Eliminated lanes from the early-modern times to now. (Source: Historical maps, Chongqingshizhi, Google Earth, etc.).

After reform and opening up, the city sped up the pace of municipal construction, the existing street lane for extensive renovation and reconstruction, upgrading the quality of the road surface. This was a major change from the 1980s when the ladder lane was built to connect the upper and lower halves of the main city to supplement pedestrian access to the road. Because of the original streets' and lanes' low widths, some were combined and restored, while others were eliminated entirely. First, the junction of Binjiang Road and four bridges; second, the nodes of Jiefangbei, the nodes of the Changchangkou, and the nodes of Chaotianmen; and third, the nodes of North District Road and Kui Xing Lou [49,55].

Focusing on the variations in road texture patterns within the sample. The first is the changing of geometric characteristics of the traffic network (Figure 8), including the

number, breadth, density of roads, etc. Arcgis provides access to the relevant data and imagery for this section. As the number of roads rises in density, it follows that more roads are being built. At the beginning of the nation, the road density of passable vehicles in the sample was 6.24 km/per km^2 until the 1980s, when the road density of passable cars in the sample was 8.31 km/km^2. The width of the three major roadways has risen dramatically, with the center arterial road increasing from the original 7 m to 32 m, the southern arterial road widening from 7 m to 33 m, and the northern arterial road widening from 10 m to 30 m [49–51], city streets are now three to five times as wide as they were back then. Technology advancement has made it possible to circumvent limits on urban road building. The construction of trunk roads along the river expanded the road space outward to the river, such as the Jialing River Binjiang Road with the rise in intra-city traffic [52,53], certain roadways were enlarged and built (Figure 8).

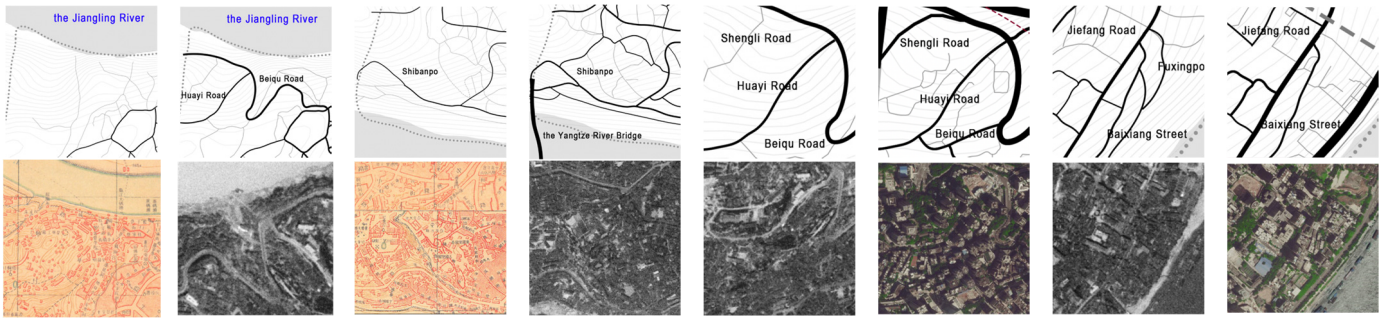


Figure 8. (**a**,**b**) Partial north main road change between the 1940s and the 1980s; (**c**,**d**) Partial south main road change between the 1940s and the 1980s; (**e**,**f**) Partial north main road change between the 1980s and the 2010s; (**g**,**h**) Partial south main road change between the 1980s and the 2010s. (Source: Open Street Map, Chongqing Street map, U.S. Geological Survey, Google Earth).

After that comes the information on integration, choice, connectivity, etc., all of which vary depending on the spatial topological structure. Depthmapx may be used to derive this information (Figure 9). Integration measures how easy it is to access both a single axis and the whole system as a whole [44]. It shows how well one street connects to others and how well one street blends into its surroundings. The results of the Depthmapx calculation clearly show that places closer to Jiefangbei have better traffic, a higher degree of integration, and a greater concentration of social and cultural life than those near rivers. As the contour line along the river is thick, and early road development is hampered by the city wall, the integration degree is low; this is connected to the " Fixation" [29] and the natural topography. The frequency with which people cross a street is a measure of the "transit traffic" in a given metropolitan area and may be inferred from the degree of its choice. If there is a lot of choice on the street, it means plenty of people walk there every day. Along the route, you can observe how the planned riverside road development would improve the flow of local traffic.

The parent city's transportation system is a dense grid created by zigzag roadways along the contour lines, which is a reflection of the layered character of the city's historical environment [56], which has developed mostly organically as a result of historical development. First, the transportation infrastructure has developed by increasing the traffic link to the city. Second, there has been an ongoing improvement to the parent city's internal traffic system, which has resulted in a traffic organization that spans all three dimensions. Roads in the parent city were scarce and displayed tree-shaped and radial structures during the early-modern era; they were features peculiar to the ancient city center, but they eventually gave way to irregular dense grid-like patterns when highways were improved. Thirdly, the micro-level road morphology of the parent city is characterized by a rise in both the width

and density of roads, as well as an increase in the quality of integration and accessibility of the road network and the openness of the street network.

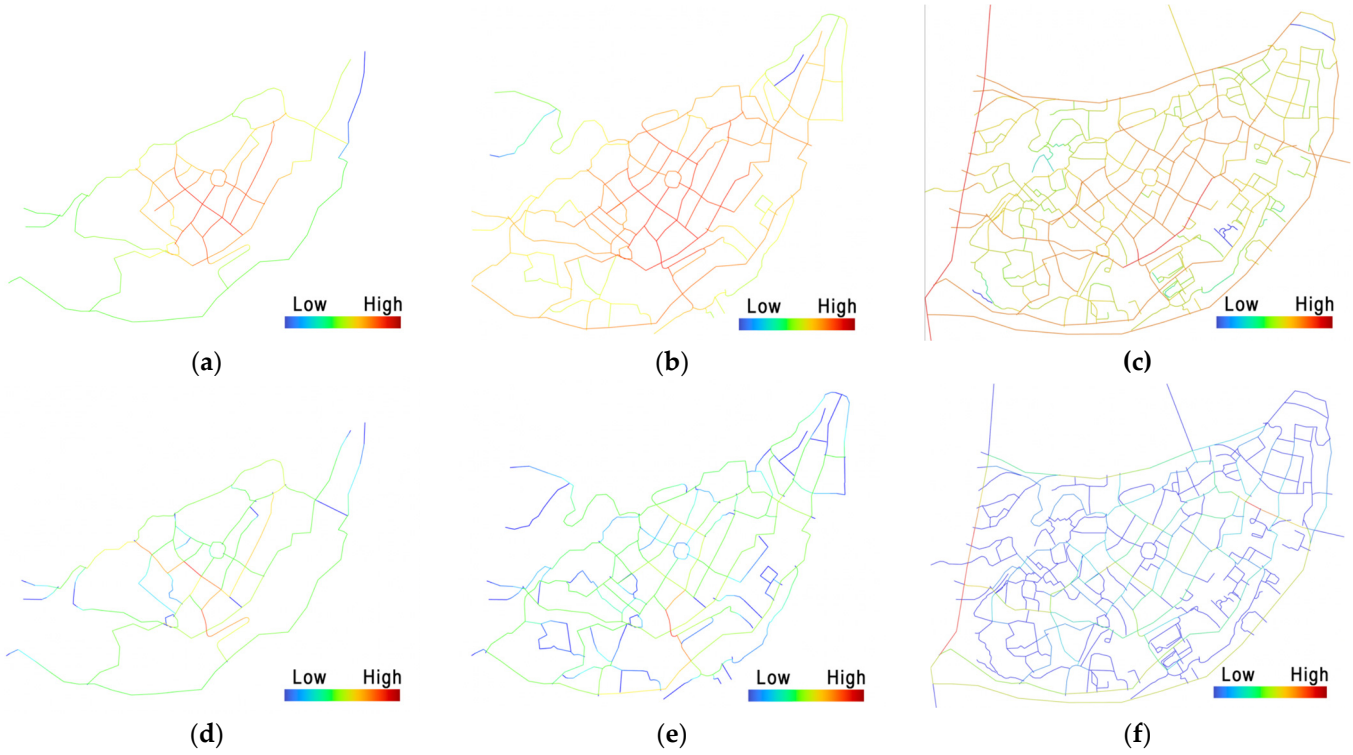
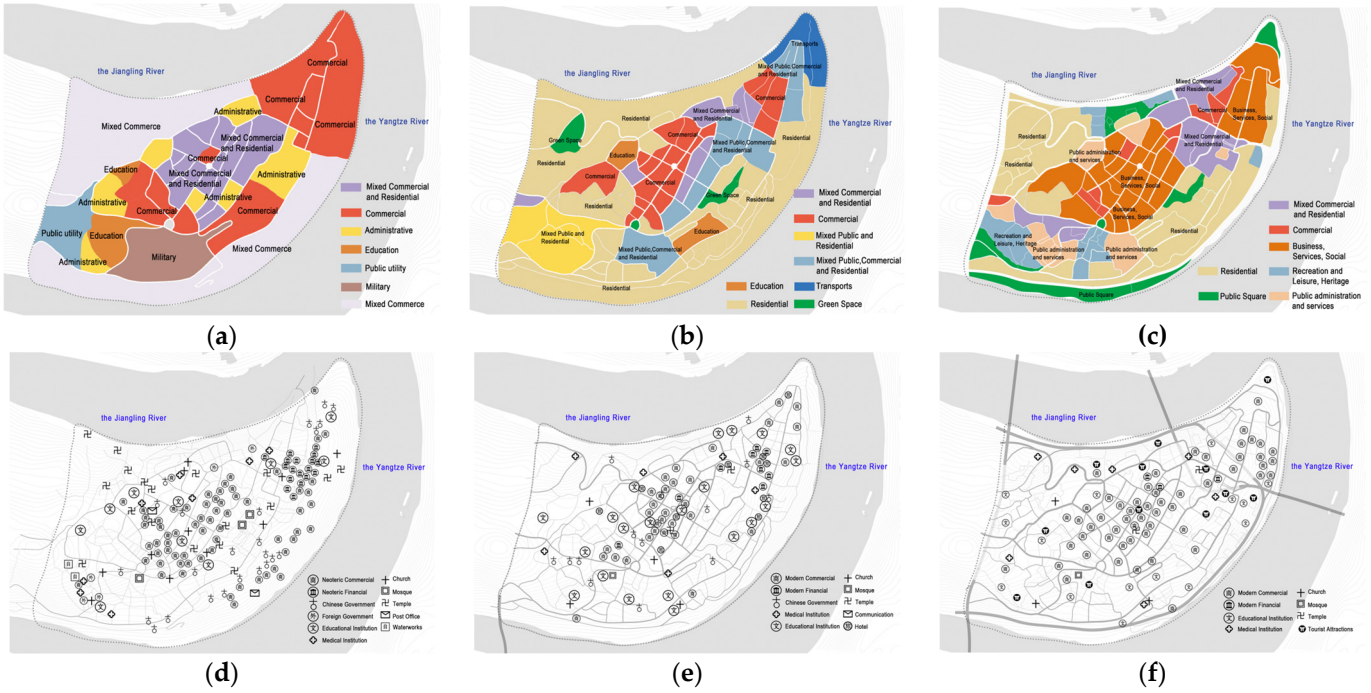


Figure 9. (**a**–**c**) Integration in the 1940s,1980s and 2010s; (**d**–**f**) Choice in the 1940s,1980s and 2010s. (Source: Depthmapx screenshot).

4.2. Transformation of Functional Space and Plan-unit

From the historic maps of functional space transformation (Figure 10), since 1949, the parent city's functions have modernized and become more complex, and the internal function structure has been constantly adjusted to rationalize and develop into the tertiary industry, which now accounts for more than 90% of the output value in Yuzhong District. Specifically, the city's administrative functions have been weakened due to two factors: first, the commercial functions have taken the form of aggregation and have been developing into tertiary industries; and second, the administrative institutions that were originally gathered on Linsen Road in the lower half of the city have been relocated to Shangqing Temple. The residential function was strengthened to accommodate the increasing population, and commercial spaces were clustered around Chaotianmen, Jiefangbei, and Bichangkou [53]. The number of commercial trade form units increased, and the appearance of commercial form units became more modern [49,54,55].

According to the geometry of plan-units, the Mother City's block contours eventually changed from being rough to having tiny grid-like block contours, giving rise to the present dense network of small block contours (Figure 11). The phenomena of block profile redivision have occurred, and the tendency of "networking" has become more pronounced. The number of block contours inside the main block profile has increased, and the size of the block profile has been shrinking. "Construction first, then planning, then transformation" construction first "free growth" block shape, mixed with planning control, describes the whole process [56,57].



(**a**) (**b**) (**c**)

(**d**) (**e**) (**f**)

Figure 10. (**a–c**) Functional Space in the 1940s,1980s and 2010s; (**d–f**) Important buildings in the 1940s,1980s and 2010s. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

The study of the turnover of components within plan-unit has been hampered by the absence of particular topographical and architectural drawings from the 1980s. In recent years, the facts and literature reveal that the turnover rate of architecture in the parent city has been more than 90% [58–60]. At the same time, the average height of buildings in the city has increased significantly, reaching roughly 4–5 stories by the end of the 1980s [47,48]. This is by far the most noticeable alteration to the period's interior space. The average height of a modern building is 33.8 m (roughly 10 stories), and the presence of numerous high-rise buildings has transformed Yuzhong District into a densely populated region characterized by its abundance of skyscrapers (the building plot ratio in this sample is 5.83, while the overall plot ratio is 3.29). These current data are derived from GIS.

Because of its dense population and rapid growth, the parent city has been redeveloped after its independence with Chinese emphasis on restoring its historic core. Therefore, there has been a process of inheritance and succession in the make-up of the plan-unit internally. Due to the stability of the street element and the fact that large-scale streets have stayed mostly unchanged since they were established, with the exception of expansion and reconstruction, the phenomena of succession can be seen in the block of plan-unit. Most of the internal structure of the plan-unit was inherited from the previous stage of slow development when small-scale progressive regeneration was the focus, and the later stage entered the large-scale regeneration stage, to modern commercial and commercial morphological units and modern residential morphological units. Early on in the large-scale renovation, most structures were demolished since their design was no longer compatible with the city's ongoing evolution.

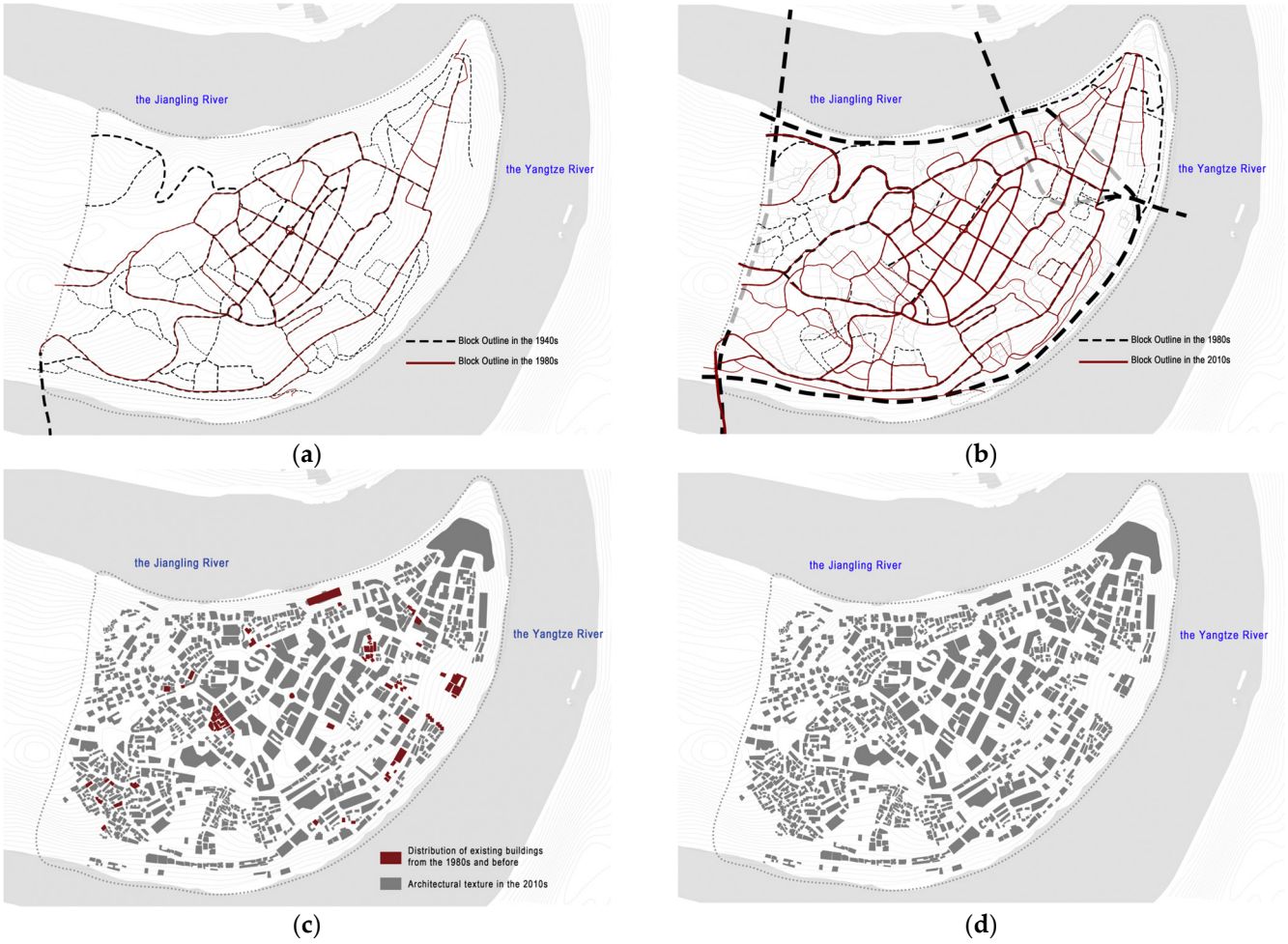


Figure 11. (**a**) Block Distribution of the parent city in the 1940s and 1980s; (**b**) Block Distribution of the parent city in the 1980s and 2010s; (**c**) Transportation network in the 2010s; (**d**) Eliminated lanes from the early-modern times to now. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

4.3. The Parent City of Chongqing in Experience and Perception

In the aforementioned study, historical maps and documents are used as primary sources to examine the historical change process of the visible portion of the historic urban landscape utilizing tools and techniques such as the spatial syntax approach, ArcGIS, and the historical map translation method. The historic urban landscape also has a perceptible component, which is often the intangible component and includes urban activities, folk traditions, and local culture. The written and visual works that document the city's evolving face may shed light on the metropolis from a new angle. Chongqing's river and boats, as well as the city's meandering alleyways and alleys, are chosen in this paper as representative cultural aspects of the river and mountain city [61].

Chongqing's expansion and development coincided with the city's location between two rivers; water transport was crucial to the city's growth and prosperity throughout the Republican period (Figure 12). It used to be that ships coming up the Yangtze from the lower sections of the river would moor on the other bank of the city, necessitating the use of ferries to travel to the city itself. Chongqing's river, docks, and boats are cultural icons that should be preserved as part of ongoing attempts to revitalize the city's historic core.

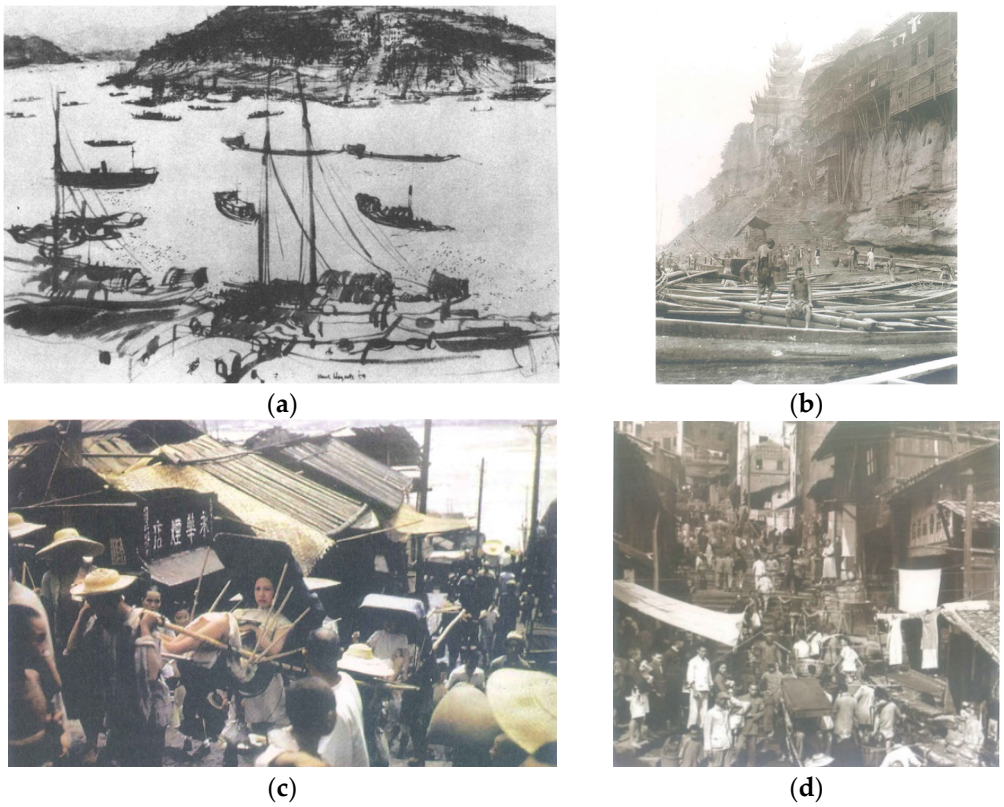


Figure 12. (**a**) Sketch of looking north of the river from Jialing wharf in the early-modern times; (**b**)Dongshui Gate in the 1920s; (**c**) Sedan chairs in Chongqing; (**d**) Stairways of Chongqing in the 1940s. (Source: Sketch by Paul Hogarth, photograph by Sidney David Gamble, William.l.Dibble and H.Allen.larsen, Life magazine).

Chongqing is built on a hilly, undulating landscape; therefore, the city's winding, tiny mountain streets, and alleys, as well as the stairways linking various heights, are distinctive characteristics. Since ancient times, the mountain city's twisting alleys and lanes have not only provided a means of transportation but have also served to interpret the personality and qualities of the area. Chongqing's unique hilly environment necessitated the adaptation of a unique mode of transportation: the sedan chair (Figure 12). Sedan chairs were often seen on the city's stone stairways. Many old streets and alleys remain today, preserving the city's unique memories from before the 1980s when urban construction was hurried forward, and the low modern hammock houses were replaced by modern high-rise houses, and after the liberation when houses could no longer be renovated due to technical and economic constraints. Urban reconstruction efforts should not destroy or drastically alter the look of ancient streets and alleyways.

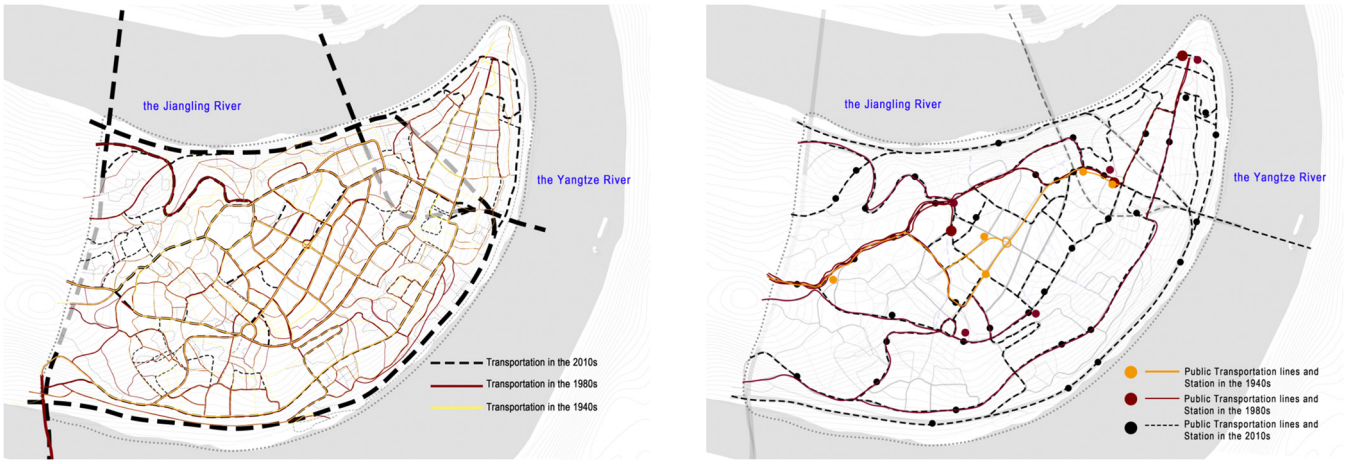
5. Conclusions and Prospects

In the past 40 years, a standardized construction mode has been universally adopted in Chinese historic urban areas as the most efficient urban planning strategy [62]. Urban regeneration is a comprehensive and integrated practice [63], and historical and traditional spaces must be adapted to modern needs, preserving historical character and regenerating these areas for adaptation to the changes ahead [64]. The tension between modern society and traditional space in China is apparent, as well as traditional to modern. The urban form bears the marks of the transition from rural to urban [65]. Urban change gradually threatens the historic areas of the city [66], and urban heritage preservation depends on the understanding of the historical evolution.

According to the methodology and framework of urban morphology, several researchers have studied the morphological changes in Guangzhou and come to the following

conclusions: the city has become denser and more functionally diverse internally [57]; the morphological units show a general characteristic of inheritance and succession; the overall structure of street space is more stable throughout the process [39], and the evolution of urban spatial form is closely related to local political, economic and cultural factors [67].

The most intuitive outcome of this research is the creation of a historical map of Chongqing using a modern map as the base map. This historical map contains information on various stages of the city's history, features the overlapping of information from multiple periods, and allows for easy comparison. Three distinct eras of contemporary Chongqing's parent city are shown in Figure 13, each with its distinct street layout and network of public transit lines, illustrating the city's sequential and evolutionary development (Figure 13). After laying the groundwork with qualitative research, the next step is to integrate quantitative methods with technological tools to compute the development of geometric, structural, and functional factors and present the results in a scientifically rigorous manner. For all other cities, this work has some ramifications.



(**a**) (**b**)

Figure 13. (**a**) The transportation network in three distinct eras; (**b**) The public transportation network and station in three distinct eras. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

The contributions and innovations of this paper: firstly, the integration of a universally suitable framework and methodology based on the use of HUL and urban morphology frameworks in conjunction with the actual situation in China. Using the parent city of Chongqing as a case to develop the interpretation, dividing the urban historical landscape into a visible part and a perceptible part, the visible part being the part based on urban morphology, exploring the planar pattern and spatial form. The perceptible part combines social activities, urban imagery, and daily life [68]. Secondly, the historical materials are analyzed by GIS and Depthmap technical tools, combining qualitative and quantitative research methods to provide new ideas for the empirical study of space. Thirdly, the study presents a technique for the investigation of spatial change in mountainous cities through the use of historical maps as a source and the spatial shaping traits of three-dimensional mountainous cities.

The study has certain limitations. The scale and precision of the research are somewhat lacking due to the absence of historical data that have prohibited the restoration of the early urban building fabric, for example, in the Guangzhou Urban Study [57], and the discussion is mainly focused on the plan, and there is a lack of discussion on land use and function. These could be used as guidelines for future research, on the one hand, to dig deeper into the historical materials and, with the help of sophisticated tools, perhaps archaeological methods, to deduce more accurate historical maps of the city, and, on the other hand, to carry out research on the internal characteristics of urban spatial form, such as function and

land use, and to consider public participation, government policies and other aspects [69], to improve and revise the existing framework and methods.

In China, large-scale demolition and construction have been common and standard in the past 40 years, and some practices have demolished the heritage and reconstructed the imitation in historic urban areas, such as "Antique Streets" or "European Streets" [62]. Some projects constructed many odd-shaped buildings and broke the historical relationship among the historic landscape [70]. These practices failed to balance conservation and development due to a lack of understanding about historic preservation.

The findings of this study may be used to preserve historic areas and serve as guides or strategies for urban planning and regeneration. Firstly, it can be used as a foundation for cultural heritage conservation, as cities with historical heritage have an advantage in the global market [71]; the findings of this study can be used to determine a location's historical spatial pattern and preserve the original pattern as much as possible [72]. The findings of this study also offer a foundation and a plan for urban planning and urban administration from the perspective of the historic urban landscape.

According to this study, some urban planning strategies can be suggested. To ensure the sustainability of the planning process, the planning horizon can be divided into three levels: point, line, and surface. At the point level, which refers to buildings and plots (Figure 1), the historical and memorial buildings should be preserved entirely [73], such as the monument to the People's Liberation, the Chongqing people's auditorium, and other landmarks. Some larger historic buildings, such as the Luohan Temple, Qing Dynasty Ba County Government Offices, and people's park, should be preserved and given new uses [73] for attractions, leisure, and other function to ensure the rebirth of historical heritage [74]. At the line level, referring to streets and street-system (Figure 1), main historic roads and rivers should be focused on, linking historic buildings and integrating them into some lined landscape that included parks and was able to accommodate a range of activities to help citizens integrate and accept the new roles [74]. For instance, Chongqing's two rivers and the wharf space have long served as a symbol of the city's collective memory, and consider reactivating the ferry routes and holding regular festivals. Moreover, the south main road, which linked Chaotianmen Wharf, Huguang guild hall, People's Park, Dongshui Gate, Nanji Gate, and other historic buildings (Figure 7a), was lined with shops of all kinds, gathering merchants from all over the world, and was also the seat of the early government in the 1920s. It should be highlighted for its historical character through regular closure of the road during important festivals to hold large fairs and trading events. At the surface level, referring to historic blocks, Chongqing's parent city could be divided into some different blocks, such as the Chaotian Gate block, Jiefangbei block, Nanji Gate block, etc.; each of them has different historical memory and characters, which should be considered as the main feature of the block. Such as the Chuqi Gate block, in ancient times, there was a folk rhyme that "Chuqi Gate, the herb house, cures all kinds of diseases", and it was still the most important market for Chinese herbal medicine since the 1920s, with many of the country's most famous old pharmacies having warehouses and shops here. In this block, Chinese herbal medicine culture could be highlighted by transforming some historic buildings into Chinese medicine halls and Chinese medicine markets. Moreover, during the regeneration process, based on the city history map from this research, the relationship between property rights, space, and resident behavior to understand the evolution of Chinese urban historic areas and internal motivation.

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