

UDC 711

Qi Yuan¹, Feihong Lin²¹*PhD candidate, College of architecture and urban planning,
Tongji University. Shang Hai, China, 200092*²*MUP, Ningbo Planning Bureau. Ningbo, China, 315000
e-mail: 342131753@qq.com*

THE RELATIONSHIPS BETWEEN URBAN MORPHOLOGY AND ACCESSIBILITY TO WATERFRONT AREA: CASE STUDY OF NINGBO THREE-RIVER JUNCTION AREA

Abstract: *The purpose of the study is to shed light on the dynamics of the link between urban morphology and accessibility through analysis of its spatial manifestations reflected in the waterfront land-cover changes over an 80-year period. This paper focuses on two inter-related areas to answer the following questions:*

1. Temporal-spatialevolution:

This paper explores how factors such as river structure, street structure, land use and property, block shape were changing in Ningbo three-river junction area.

2. Syntactic analysis of the streetnetwork:

Through the structural modeling of the street network, the integration degree, selection degree and connection degree are calculated, and the accessibility diagram is obtained at each stage. The results of the morphological analysis of temporal-spatial evolution can be used for the prediction of their futuredevelopment.

Keywords: *urban morphology, land use, accessibility, waterfront area, space syntax.*

Research background

There are many ancient cities in the south of China. These cities are rich and diverse in form, most of them are water centered, and the urban space formed by streets and lanes. From the perspective of urban development history and urbanization process, most of the waterfront areas of these cities have experienced three stages of development:

Pre-industrial period—mixture of the waterfront and urban daily life

The city was first located at the intersection of rivers, and the waterfront area of this period was characterized by natural development. Agricultural irrigation, water supply, drainage and transportation are the most basic functions of the river in the pre-industrial period. With the formation of ports and markets, the waterfront area had become the most dynamic commercial center. In another words, the structure of the river was not only the skeleton which supported the spatial development of the ancient city during the Pre-industrial period, but also an important link of contact with the outside world. The streets of the ancient city were the artificial environment system which was dependent on the continuous growth and perfection of the natural river channel, they connected the living space and activities separated by the river channel. The river and the streets were interdependent and mutually reinforcing, they became a diachronic of the local way of life in space accumulation, and it gradually solidified space form also affected and standardized the local resident's daily behavior and habits, which presented continuous debugging and interaction between the urban space and social self- organization characteristics. (XiuchangXin,2015)

Industrial period—The waterfront areas existed as industrial spaces firstly, and life function was excluded.

After the industrial revolution, the waterfront area was occupied by landmark industrial buildings such as factories, docks and warehouses. Industrial water supply, drainage and transportation became the primary function of the river during this period, and the waterfront area was controlled by industrial space and suffered from serious pollution. The waterfront area became the urban fringe space. As a result, the evolutionary process was challenged.

Post-industrial period—The waterfront area was re-developed into a core area of urban public activities.

After the 2000s, with the rapid transformation of the transportation mode (shipping was gradually replaced by the land traffic such as roads and railways) and demand of urban expansion, the shipping function has been gradually weakened and transformed to urban public leisure space. Based on the latest demands, people's behavior characteristics are focused. As an important public urban living space, the vitality of the waterfront area is highly focused. However, in this process, the waterfront has been lacking vitality. Weak connections between the two sides of the rivers have also led to huge vitality differences.

In order to explain what methods were used in response to the transformation, questions below should be asked: Has the urban form of three-river junction area changed in the historical process of functional transformation? What has changed? And finally, how does the urban form affect the accessibility of the waterfront area?

As we know, the vitality of the city is inseparable from the behavior of the crowd (Jacobs, 1961). There has been a mathematical prediction of the powerful effect of spatial distribution on the flow of people (Hiller & Lida, 2005). Therefore, to find out the relationship between urban morphology and accessibility to waterfront area is an effective way to answer the questions above.



Pre-industrial period



Industrial period



Post-industrial period

Figure 1. Urban morphology of Ningbo three-river junction area in different periods

Ningbo three-river junction area—From the edge to the center.

As the birthplace of Hemudu culture, Ningbo was first built at the intersection of the Yong river, the Yu Yao river and the Feng Hua river in 821. Ningbo is China's second batch of national historical and cultural cities which has more than 1,100 years of long-term stable urban development history, because there were not too many wars and natural disasters, the basic urban structure, landscape and traditional environment has not been broken. Ningbo is a typical plain water network geography environment, which has three sides facing the mountain and one side facing the East China Sea. As the terminal of the grand canal, Ningbo has become an important hub for the handover and transshipment of the ancient South China Sea which also played an important role in shipping and inland water transportation. The three-river junction area was the origin of Ningbo, which was not regarded as the center of the whole city until the 20th century, and has gradually become the most concentrated waterfront area in the city.

The transformation of the water network to the road network.

In the tang dynasty, Ningbo was called “Luo Cheng”. It was formed by two great rivers (the Yao river and the Feng Hua river) and two creeks (the Xi Tang creek and the Nan Tang river). The city walls were built along the surrounding river system. The ancient city lies on the western side of the three-river junction. The river channel was densely covered with the well pattern, and some parts were adjusted with the trend of the water system. The ship was the main vehicle at that time, and streets and water systems were interwoven. The street structure was a typical spatial pattern of a water town. After the opening of Ningbo in 1840, the rapid development of foreign trade promoted the construction of the city, and the urban street pattern became more and more clear. By filling some of the creek and widening the streets (the east-west street such as Zhong Shan road, Yao Hang street, Sha Ni street and the north-south street such as Xiao Wen street, JieFang road, Zhen Ming road, Kai Ming street), the north-south trunk road network was developed. With the gradual transformation of the water network into the road network, the transportation mode also gradually turned from water transportation to the ground transportation.

Urban areas extend across the river.

In 1910, the first railway station in Ningbo was built in the north of the junction (the suburbs of the ancient city). The construction of the railway station strengthened the connection between the ancient city and the region across the river and the urban area began to spread. The city wall of “Luo Cheng” was demolished during the first half of the 20th century, and the new road was built in the demolition site.

The key area of the dock is shifted north.

Construction of the railway station promoted the development of transportation and foreign trade, a large number of trading companies, postal companies, banks and other businesses started to develop on the western side of the Yong river bank (along the Wai Ma road). The original cargo berth also moved north to 500m, and in 1936 the number of docks was 14 (an average of one dock per 100m to 200m). Various trade activities have also contributed to the development of this region, a large number of foreigners lived here and built a lot of smaller blocks of 100m*100m or 50m*100m.

Methodology

This paper compares the differences of streets structure and land uses between the pre-changing and post-changing period through the study of spatial diachronism. The influencing mechanism is explored. “Space syntax” provides a systematic description, model construction and objective analysis method for the study of spatial morphology of the three-river junction area. Space syntax is based on the theory of environmental perception and space experience of moving people (especially walking activity), focuses on urban space visual permeability to summarize the influence of people’s activity, which helps to analyze how residents understand and feel the complex network structure of urban streets. The extraction of the morphological variables of the area mainly adopts the analysis method of the “segment model”, which is to construct the segment graph of the area by comprehensive analysis of the topological, metric and geometric structure of the street network. The relationships between segments are measured by a series of configuration variable indicators. The commonly used indicators include Integration, Choice, Connectivity, Control and Depth. The Integration is used to investigate accessibility of the segment to all the other relative segments in the system. The region composed of the axis with the highest degree of Integration (5% of the total axis) is called Integration core, which is often used in space syntax to indicate the high public accessibility of the region. The Choice represents the probability that the segment is passed between any two segments of the system. In addition, other environment information on the three-river junction area such as land use, retail along the street, street furniture and environmental quality was mainly acquired through field investigation, historical maps and local history literature.

Measurement and analysis

This paper selects the map of the two periods in 1936 and 2017 of China and analyzes the morphological characteristics and evolution process of land use of Ningbo three-river junction area in the past 70 years. The road map of the republic of China in 1936 is the most complete historical map. At the same time, the ancient city of Ningbo was relatively intact, and the residential population and urban construction reached the mature stage. After that, because of the war and political reasons, the city experienced a long period of slow construction until the 1980s.

Integration of the walking network

By comparing the map of two periods, it can be found that in the process of street reconstruction, many alleys and end roads have been cancelled, and most of the fast roads are connected to form a network. For example, the Yao Hang Street was connected with Liu Ting Street, and the width of it was doubled, so as to adapt to the traffic changes in the automobile age. Although this kind of practice promoted the accessibility level of vehicles coming from the west, cancellation of the alley has greatly reduced route choices of the pedestrians. They have to use the urban expressway, on the other hand, widening of the road also increases the time and difficulty of crossing the street, which is also related to the reduction of accessibility in the waterfront. In 1936, the average block size was 100*150, and in 2017, with the cancellation of the branch road, many small blocks were merged into bigger ones, and the size increased to 200*200, or even 200*300.

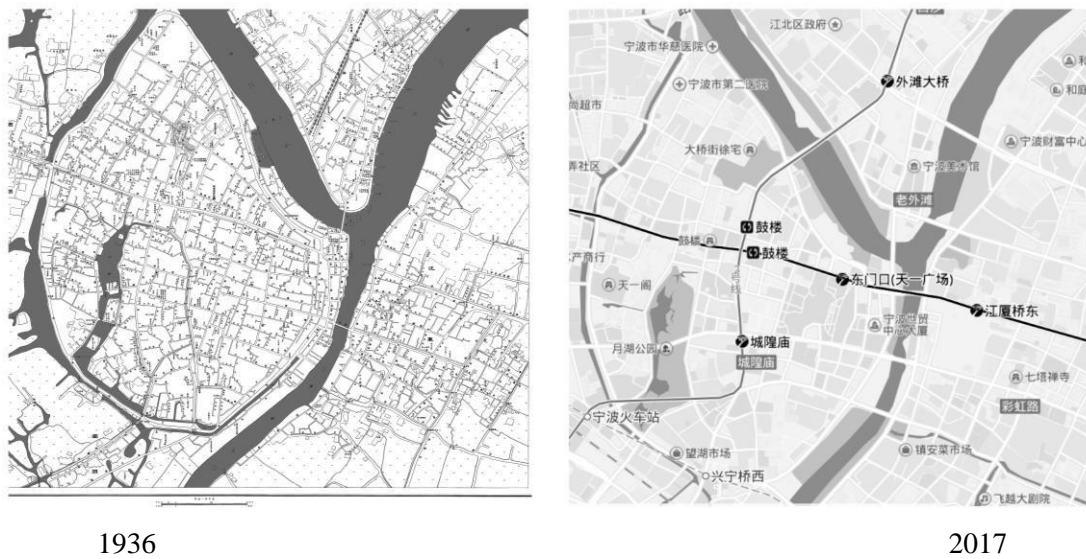


Figure 2. Comparison map of Ningbo three-river junction area street lane in different periods

300m and 1000m were selected as the main research radius to study the difference of accessibility between pedestrians and vehicles respectively. According to the results of Dethmap, when the radius is 300m, the number of line segments with higher integration degree (the top 5%) in the road network structure in 1936 is significantly higher than that in 2017, which reflects the convenience of walking in 1936 as the main mode of transportation. When the radius is 1,000m, the calculated data shows similar results. This data shows that, although the method of connecting the main road and reducing the alley seems like promoting the efficiency of the motor traffic, in fact, it did not really increase their accessibility in the city, for both pedestrians and drivers. On the contrary, there is a smaller amount of paths they can choose from than before.

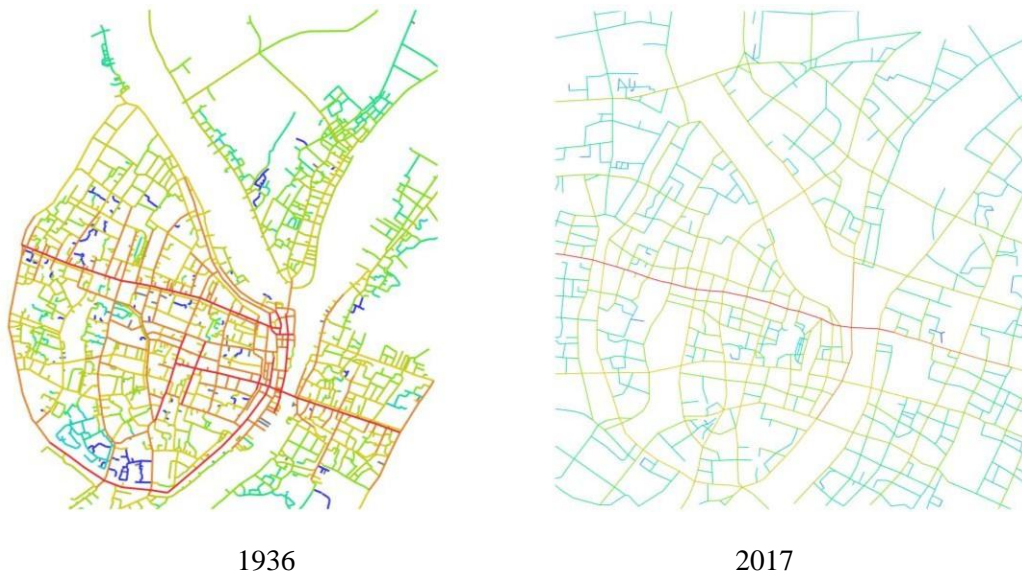


Figure 3. Integration core (R=300) in different periods

By comparing the position of the integration core (the whole city) in the two periods: the integration of the whole city core appeared to move northeast, from the ancient city center to three-river junction area. This is because seven new bridges across the river have been built, connecting the main roads in three regions. However, the integration core of the ancient city itself shows the trend of moving southwestward, which reflects the development trend of multi-centers in the big cities.

	1936(R=300m)		2017(R=300m)	
1	Bai Zhang road	674	Zhong Shan road	592
2	Jiang Xia street	667	Jiang Xia street	520
3	Yao Hang street	666	Jie Fang Nan road	510
4	Zhong Shan road	662	Liu Ting street	494
5	Kai Ming street	630	Da Sha Ni street	485

Since the value of integration is relative, there is no possibility of horizontal comparison.

When the radius is 300m, the difference among the high integration number street is quite small (within 50) in 1936, while it is much greater (more than 100) in 2017. It shows that the degree of uniformity of the integrative core area has reduced. In addition, the highly integrated streets of 1936 were connected, and in 2017, most of these streets did not intersect directly.

In 1936, both transverse and longitudinal roads along the river show high integration degree, reflecting high accessibility of the riverside road network. However, in 2017, only one main road (widened five-lane) that is parallel to the river has a higher degree of integration, and there are rare roads perpendicular to the river which have generally lower integration. If a pedestrian wants to reach the waterfront, there is no doubt that he needs to cross the wide road. Therefore, according to the calculated results of space syntax, the existing street structure is more suitable for the residents of surrounding areas, for vehicle users or pedestrians who live a little far from the waterfront area, and it is not a convenient urban public space.

Land use

No matter in 1936 or in 2017, the most accessible area in the waterfront is located at the south side of the three-river junction. Is it a coincidence or is there a necessary connection?

In 1936, the land use of the ancient city was mainly residential. Due to the prosperity of the freight trade along the river, the public facilities were more abundant and the commerce was concentrated at the riverside. Later, in order to be able to increase the publicity of waterfront space, many large public facilities have been built in the riverside. Although a more beautiful urban landscape was formed, the diversity of behavior has been reduced.

In 1936, only Zhong Shan road ran through the ancient city, and because the three-river junction was the main area of trade transportation, this road was the only one that could connect three regions across the river. There was no possibility to avoid the road if someone wants to go from the north to the south. This area also has a high density of road network, which satisfies this special traffic crossing.

In 2017, though the road was not as important as it once was in 1936, it is located in the most commercially concentrated region with shifting of the city center. Compared with the surrounding lands have already been merged, it still keeps the original state of road density. Although this road is considered to be the main road for motor vehicles, but it still shows a higher walkable accessibility.

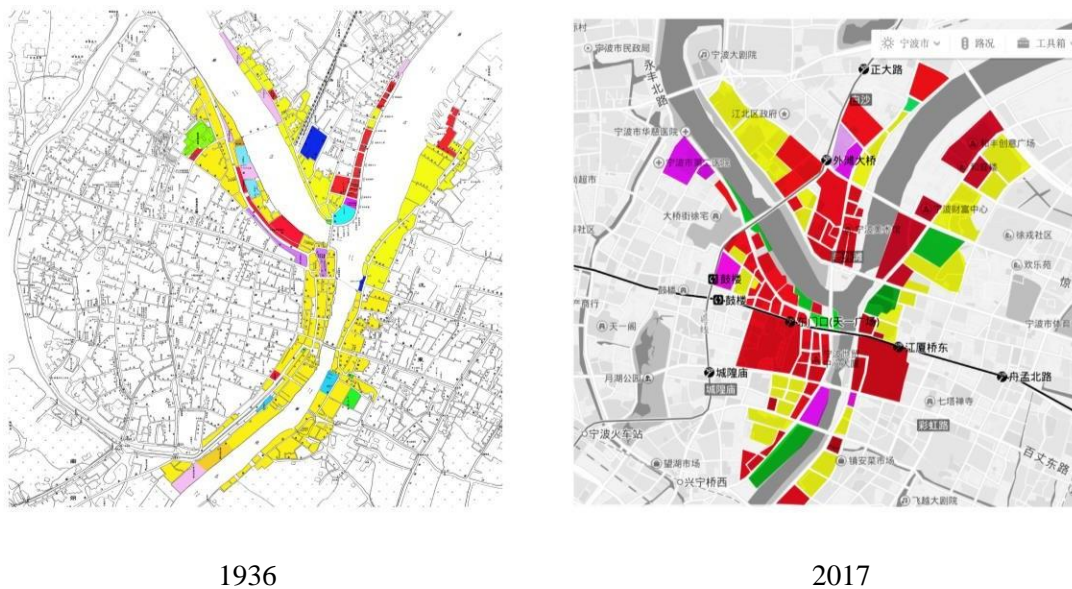


Figure 4. Comparison map of Ningbo three-river junction area land use in different periods

Although the small blocks merge with many large green parks right now, in terms of contemporary lifestyle, a green park is more attractive for the elderly, because they like to go for a walk and breathe fresh air, their behavior is relatively simple including sports, playing chess or having a rest.

Although a large number of urban public facilities, such as concert halls and theaters were built along the river, these facilities tend to have relatively concentrated opening hours, such as when there is a performance. Therefore, these massive buildings are not closely related to the daily life of the surrounding residents. Moreover, these buildings often obstruct the visibility of the waterfront environment, the famous three-river junction cannot be even seen from the road.

Some big expensive residential or commercial buildings such as hotels, often cut off roads along the river and turn the space to private space. This approach reduces the continuous degrees of the road along the river, especially the walkway.

Conclusion

Based on the development background of Ningbo three-river junction, through the way of qualitative analysis, this research studied the reason for the current lower accessibility of the three-river junction waterfront area. The road network structure model was established by space syntax, the conjecture was explained and proved.

In order to adapt to the motor vehicle traffic patterns, the road structure was reconstructed and changed, but these measures which were supposed to improve the waterfront accessibility did not play a positive role. Variations in the accessibility of the waterfront area exist not only between the different land use categories but within the particular land uses themselves. Analysis of accessibility in the context of the research has revealed that the impact of proximity to the commercial land use on the distribution of walking activities is continuously weakening, while the integration of streets is becoming more and more important. The results of the morphological analysis of temporal-spatial evolution can be used for the prediction of their future development.

References

1. Anas, Alex, Richard Arnott, and Kenneth A. Small (1998). Urban spatial structure. *Journal of Economic Literature* 36(3): 1426–1464.
2. Dai X L. *The Chinese city Suzhou in seven hundred years: an investigation of the relationship between the changing functional pattern and its spatial structure in the urban transformation process.* London: University College London, 2004
3. Handy S. and Niemeierd. A. (1997) Measuring accessibility: an exploration of issues and alternatives, *Environ. Plann. A* 29,1,175–94.
4. Hansenw. G. (1959) How accessibility shapes land use, *J. Am. Inst. Plann.* 25, 73–76
5. Hillier B. *Space is machine: A configurational theory of architecture.* Cambridge: Cambridge University Press, 1984.
6. Ingramd. R. (1971) The concept of accessibility: a search for an operational form, *Reg. Studies* 5, 101–07.
7. Mahmassanih. S., Baajm. H. and Tongc. C. (1988) Characterization and evolution of spatial density patterns in urban areas, *Transportation* 15(3), 233–56.
8. Xiuchang Xin. (2013) 'From Production Space to Living Space: reflection For Changes of Urban Waterfront Functions in the Post-Industrial', *Urban Development Studies.* 4 (22) 2015