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The Influence of Water Form on Urban Fabric -- A Case Study in Nanjing Baguazhou

Ying Liang[1], Quan Liu[2]

[1, 2] School of Architecture and Planning, Nanjing University, China

[2] Corresponding Author, e-mail: liuq@nju.edu.cn

Abstract

The classical urban morphology focused on artificial elements, while the ignored natural factors, especially water system, have a very important impact on the formation of urban form. We took Baguazhou, Nanjing, China as a study case, to discuss the intimate relationship between the evolution of the river system, road system and building fabric of Baguazhou. Through geography study and historical maps analysis, this paper figures out the formation process of the river system of Baguazhou in Yangtze River. Then, this paper represents the water system transformation, residential developing process by literature reviews. Finally, with the typology study of series of slices of typical river, we analyse the layout relationship between river, roads and buildings, so that proving the influence of river shape on the formation of urban fabric.

Keywords: *River system, Yangtze River, Urban fabric*

Introduction

The development of city is affected by two cooperative factors, natural and human forces. Although we have noticed human factors have more and more influence on urban spatial form, we still cannot ignore the objective effect of natural factors on urban form. The emergence and development of city is mostly originated from river, which also cultivated human civilization and urban culture, as well as the spatial structure of city (Morris, 1972; Dong, 1989; Wu, 1991; Xing and Chen, 2007). However, the classical urban morphological research mainly focus on the artificial elements: streets, plots and buildings (Conzen, 1960; Moudon, 1997). Kropf (2014) and Osmond (2010) expanded the frame to the open space and some natural elements, the study on the interaction of urban water system and the traditional morphological elements are still scarce. Therefore, it is necessary to explore the influence of water system on the formation and evolution of urban fabric based on the existing studies.

Nanjing is located in the southwestern part of Jiangsu Province, China, in the mainstream of the lower reaches of the Yangtze River. The morphological changes of the Yangtze River and its tributary Qinhuai River are closely related to the formation and development of this city. Baguazhou Island is the biggest ait in Yangtze River of Nanjing section, which remains internal river system during the formation process of the ait. Based on series of historical maps and field research, this paper discusses the evolution of water system and the settlement's situation in Nanjing. We selected series of sections (300m × 300m each) of the typical river and

analysed from the aspects of the type, direction and function of water system, as well as the orientation and distribution of roads and buildings.

The morphology of internal rivers of Baguazhou

The evolution of Nanjing reach of Yangtze River

The Nanjing section of the Yangtze River starts from Xiashan Mountain and down to the Siyuan River, which is 73km long and has a total length of nearly 200km along the river bank. There are four narrow sections (Figure 1), and the open sections between the narrow sections form three aits, namely Meizizhou, Baguazhou and Xinglongzhou (Chen, 1988). Baguazhou is the largest of the three aits and the third largest in the entire Yangtze River (Zhang, Zhao and Zhang, 1990).

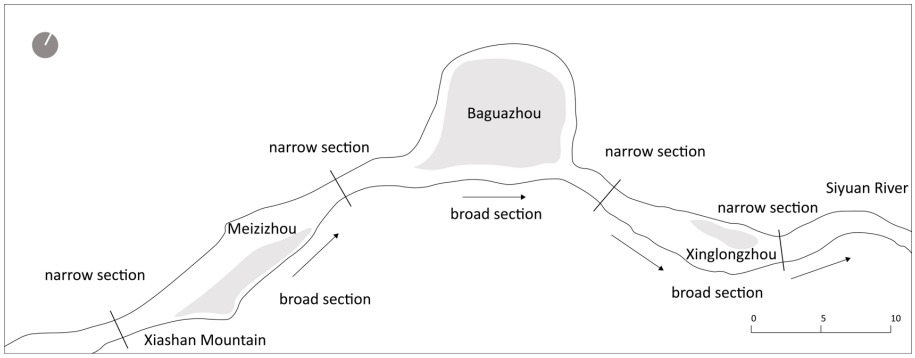

Figure 1. *River regime of Nanjing reach of the Yangtze River.*

At the beginning of the New Tertiary, the Yangtze River gradually connected and flowed into the sea in the east (Yang, 1985). Since the Mid-Holocene, the main characteristics of the river bed evolution in the Nanjing section of the Yangtze River are: continuous narrowing and deformation of the river bed, widening and increasing of the floodplain; accumulation in the river bed is dominated; the form of riverbed plane is wide and narrow, like the lotus root. (Figure 2) (Pan, 1990). The development process of ait of Yangtze River consists of four stages: sedimentary core beaches and frontier beaches; enlargement and increase into river core continents; evolving into a multi-continent and multi-branched river channel; Single branch and double branch transition (Pan, 1990).

Left and right branches of Baguazhou

According to historical records, Baguazhou was formed at least 1700 years ago (Chen, 1988). Before the 1940s, the left branch was the main branch, and the Baota waterway was a large smooth bend; the right branch was a minor tributary, and the river was narrow and curved. After the 1940s, due to changes in the river bed upstream of the branch, the Baguazhou head collapsed, the left branch gradually declined, tended to bend and transformed into a minor tributary, and the right branch became straight and the river length decreased and transformed into the main branch (Figure 3). (Chen & Liu, 1999).

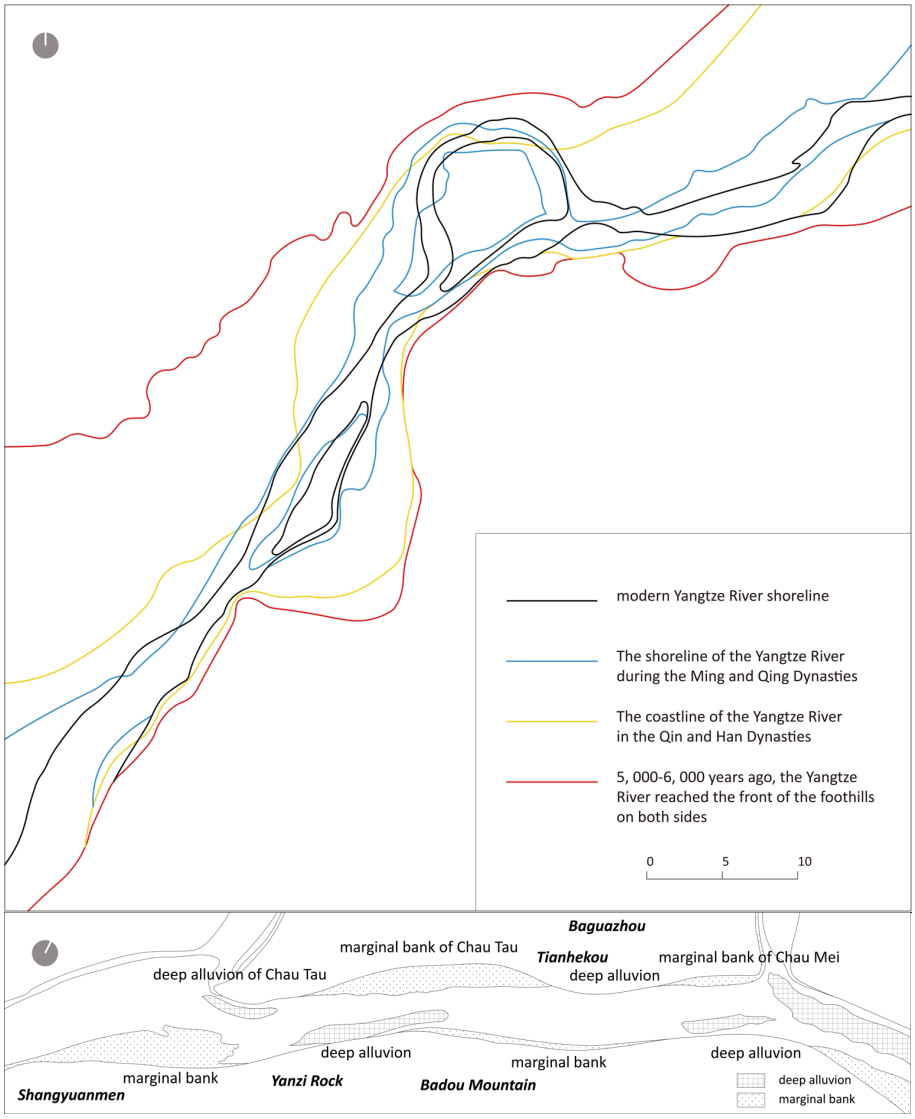

Figure 2. *The river bed change map of Nanjing reach of the Yangtze River.*
Figure 3. *Sketch map of beach tank ' s right branch of Baguazhou in 1993.*

Internal rivers of Baguazhou

From the historical map (Figure 4), it can be seen that before 1936, Baguazhou was originally composed of multiple small sandbars. The internal river channel was complex and multi-branched. The basic trend of the river channel was the same as that of the right branch of the Yangtze River. By 1951, some internal river channels had narrowed and disappeared, and they were no longer connected to each other. Several small sandbars merged into one large sandbar, and the river channels showed a simple bifurcated shape. By 1983, with the exception of the Xiaojiang River, other natural rivers running east-west were gradually straightened, and artificial rivers running north-south appeared, such as the Yuejin River, eventually formed the current internal river network of Baguazhou (Figure 5). Based on the analysis of the historical evolution of rivers, the internal rivers of Baguazhou can be divided into three types: natural, transformed, and artificial (Figure 6).

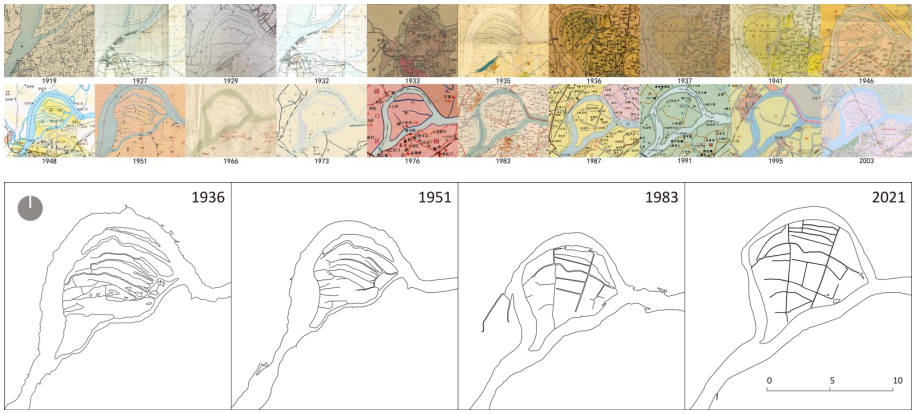

Figure 4. *Historical map of Baguazhou (From 1919-2003).*
Figure 5. *Redraw according to typical historical map. From left to right showed 1936, 1951, 1983, 2021' s figure of Baguazhou' s riverway.*

Distribution of settlements

Baguazhou has seven administrative villages (Figure 7), which belong to a typical island settlement system (Cui & Yan, 2020； Zhang et al., 2021). The settlements of Baguazhou are mainly distributed on the banks of the two rivers, Xiaojiang River and Yuejin River (Figure 6). The Xiaojiang River is the longest and widest natural river in Baguazhou, with a total length of 8.6km. The Yuejin River is the main artificial river channel connecting the north and the south of Baguazhou. It is about 5.8km long. It intersects with the Xiaojiang River in the east of Baguazhou and connects with the Yangtze River in the south. These two rivers form the main structure of the cross-shaped river network and influence the layout of buildings and streets.

In 1684 AD (the 23rd year of Emperor Kangxi in the Qing Dynasty), sporadic immigrants began to live in the southwest corner of Baguazhou (known as Qilizhou at that time). In 1712 AD, villagers began to open up wild land on the island (Wutongzi, 2014). During the Republic of China (1912-1949), Baguazhou was reclaimed four times. In 1929, the Nanjing Special Municipal Government released 22,000 acres of land under the principle of "high land and scarce firewood". The upper and lower sections of the Jiangzihao and Dashatan were the first batch of reclamation areas (Figure 8). In 1934, more than 5,000 acres were released. In 1936, the municipal government released 7,000 acres of land in the reed land within the new ridge. In January 1937, it reclaimed 6,000 acres, including two parts from the Waisabao to Xiaba and from Xiaba to Tianhekou (Zhou, 1997).

It can be seen from the satellite image that the architectural texture on both sides of the Xiaojiang River is significantly denser than that of other rivers (Figure 9). This may be due to the “high ground” here and it was the first land reclamation on Baguazhou at that time. The building texture on both sides of the Yuejin River is also the densest artificial waterway in Baguazhou. Therefore, the following will further discuss the two typical rivers, the Xiaojiang River and the Yuejin River, and the architectural textures on both sides.

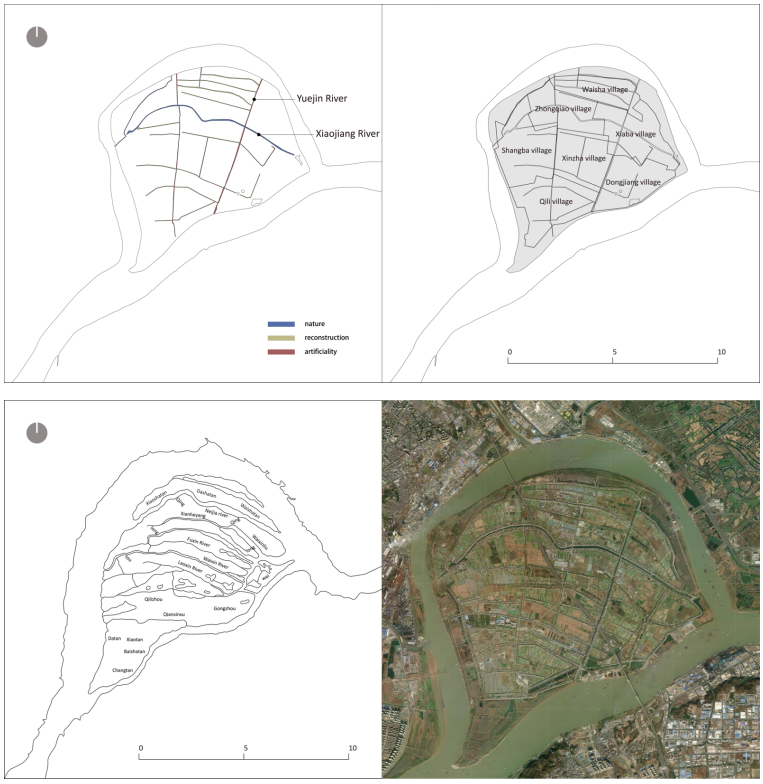

Figure 6. *Classification of river types in Baguazhou. Blue represents natural channels, yellow represents modified and straightened natural channels, and red represents artificial channels.*
Figure 7. *The administrative village division of Bagua village.*
Figure 8. *Map of Nanjing in 1936. Redraw according to typical historical map.*
Figure 9. *Satellite map of Baguazhou in 2021.*

Morphological relationship of river, building and street

Types of river

This article takes the Xiaojiang River, Yuejin River and the buildings and streets on both sides as the research object, and makes continuous slices with a scale of 300m×300m, and conducts a type study of the slices (Figure 10). Firstly, the types of water systems can be roughly divided into two categories: linear and cross (Figure 11). Linear rivers include east-west, north-south, oblique (angle>20°) and curved rivers, which can be further subdivided according to the vertical and parallel relationship between the river and the road. Cross-shaped rivers include cross-shaped, T-shaped and asymmetrical cross-shaped. The statistics of the proportions of each type are shown in Table 1.

As a representative of natural rivers in Baguazhou, Xiaojiang River are mainly linear rivers, the east-west and oblique river sections account for 70.6%, the curved river sections account for 20.6%, and the intersecting river sections account for 8.8%. As the representative of artificial river, Yuejin River are also mainly linear rivers, with 68.2% of the total river sections in the north-south and oblique river sections, and 31.8% in the intersecting sections.

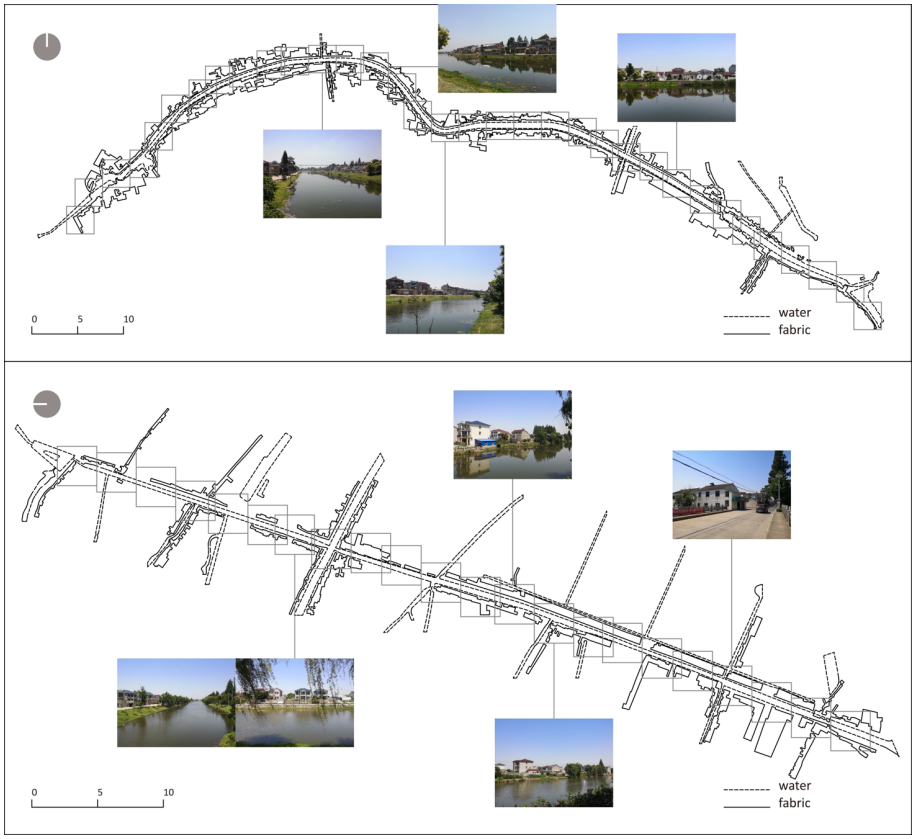

Figure 10. *The Xiaojiang River and Yuejin River were respectively researched with the sections of 300m×300m. 34 sections in Xiaojiang River and 22 in Yuejin River.*

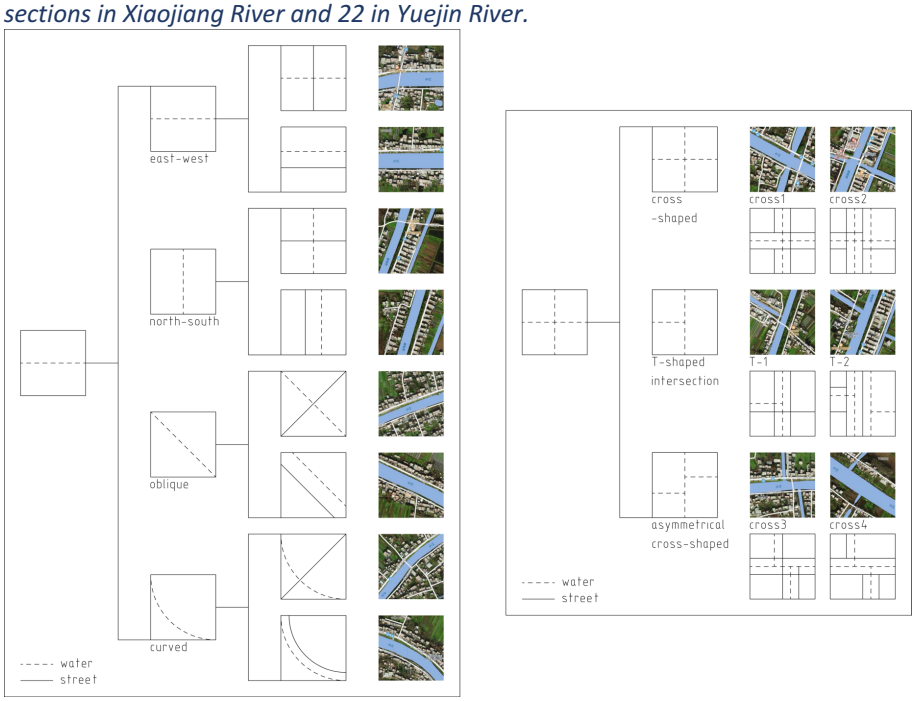

Figure 11. *Water system can be divided into linear and cross types.*

Relationship between river and street

Both sides of Xiaojiang River have streets parallel to the river, most of which form multiple rows of streets. Among them, streets are close to the river in 27 sections, accounting for 79.4% of the total. Buildings are sandwiched between streets and rivers in 7 sections, accounting for 20.6% of the total. In addition, 28

sections (82.4% of the total) show streets are perpendicular to the river, of which 64.3% are end roads and 35.7% are connecting roads.

Both sides of Yuejin River have streets parallel to the river, most of which form multiple rows of streets. 10 sections were close to the river, accounting for 45.5% of the total. Buildings are sandwiched between streets and rivers in 12 sections, accounting for 54.5% of the total. In addition, 19 sections (86.4% of the total) show streets are perpendicular to the river, of which 47.4% are end roads and 52.6% are connecting roads.

Table 1. Statistical table of various slice types of Xiaojiang River and Yuejin River.

Classification	Line Type				Cross Type		
	East-West	North-South	Oblique	Curve	Cross-shaped	T-shaped	Asymmetrical Cross-shaped
Xiaojiang River (34 sections)	6	0	18	7	1	0	2
Yuejin River (22 sections)	0	8	7	0	3	4	0

Relationship between river and buildings

The buildings on both sides of the Xiaojiang River are mostly built facing the river channel along the river. As an artificial river course, the Yuejin River runs from north to south as a whole; the building texture on both sides is regular, and the building orientation is basically parallel to the river course, and is not built facing the river course. This shows that the orientation has a greater influence on the arrangement of buildings than the direction of the river (Figure 12).

Figure 12. *Satellite images of Xiaojiang River (left) and Yuejin River (right).*

Conclusion

Based on a series of historical maps and field research, this paper took Baguazhou as a case study, selected several typical slices, to explore the influence of water system on the formation and evolution of urban texture. First of all, the river channels in Baguazhou were divided into three different types: natural, transformed and artificial river channels. Secondly, Xiaojiang River and Yuejin River were taken as the typical

natural and artificial river channels respectively. Then, after we divided the river system into linear and cross types, this paper discussed the relationship between river channel and road, so that the proportion of each type of the river slices in the whole river can be estimated. Finally, we discussed the difference between the water form of natural river channel and artificial river channel, and also the building texture on both sides.

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