

A study of Chinese traditional Duotian settlement combining morphological analysis

Jiao Yang¹, Andong Lu²

¹ School of Architecture and Urban Planning, Nanjing University. Nanjing, China

² School of Architecture and Urban Planning, Nanjing University. Nanjing, China

Abstract

The Lixiahe Region is a low-lying wetland that used to suffer from frequent floods due to a complex historical hydrological environment. This region is situated between the Huaiyang Section of the Grand Canal and the Yellow Sea. Islands of arable higher lands were formed by digging small rivers and deep ditches in the marsh by accumulating mud. Therefore, the method called Duotian became the land utilisation method against floods and can be traced back to over 600 years ago. Tens of thousands of islands (for production or living) in various forms, water systems, and wetland form a Duotian settlement and typical landscape in Lixiahe Region. As an ecological-social system, Duotian first supports stereo-agriculture through the combination of islands of geometrical shapes and height, which adapt to the special water environment and the production organisation. Second, Duotian also alters the water network's direction, depth, and density, thus providing corresponding supplements of natural substances, watering convenience, and transportation. In this paper, Duotian is regarded as the product of the co-existence of humans and water. It is expected that the research method in morphology will help reveal the control mechanism of the supporting environmental adaptability of Duotian. First, based on a field survey of Duotian and data collection, the operation mechanism of the Duotian settlement system has been described. Then, with selected typical samples and the method of Conzen School, the morphological elements of the Duotian plan were subsequently analysed. This morphological study of Duotian helps with a more comprehensive interpretation of the morphological mechanism of built environment in the Lixiahe Region and the establishment of holistic cognition of sustainable development in the complex waterfront human settlement environment.

Keyword: Chinese wetland settlement, Duotian, plan analysis, typomorphology, built environment

Introduction

Humans have preferred to inhabit areas in close proximity to water since ancient times, as water contributes to a flourishing economy and society. It is forecasted that 1 billion people will live in low-lying coastal areas and deltas by 2050 (McMichael et al. 2020). The harnessing of water has been a necessity for the sustainable development in low-lying coastal areas to construct a social-ecological system that supports humankind's prosperity and its capacity to recover from calamities quickly.

Currently, a consensus requiring cross-discipline efforts has been reached to meet these requirements. Meanwhile, such a consensus also entails new challenges to urban morphology. The cause of these challenges are as follows: when arising from social and ecological perspectives respectively, the openness and dynamic features of the social-ecological system often result in a disparity between the means of description and objects of description in the morphological delineation (Marcus, Berghauer Pont, and Barthel 2019). Therefore, there is a need to expand the study case types, morphological patterns and

resolutions, especially for more ecologically sensitive cases. It will help develop a more comprehensive approach to urban morphology research and support practice of targeted at SDG₁₁.

In this paper, the Lixiahe Region being described is a famous low-lying place in East China with a complex historical hydrological environment. Due to enclosed traffic environment and constant floods, the advent of urbanisation in this region has been stalled, with the retention of most morphological characteristics of a primitive waterfront human settlement environment. Duotian is a particular form of farmland in Lixiahe hinterland to harmonise agriculture and the water environment. It is a unique way of water and soil utilisation with a history of over 600 years. Through the digging of small rivers and deep ditches, farmers build high islands with accumulated mud for farming and irrigation (Figure 1). The settlements and the surrounding Duotian together form numerous archipelagos (Figure2), which require considerable social and natural resources to build and maintain.



Figure 1. Duotian in Lixiahe region,1978. Photographer: Houming Hu

Figure 2. A birds-eye view of a Duotian settlement in Lixiahe region,2019. Photographer: Pinpang Hangpai

Based on the case discussion of the Duotian settlement, those intertwined social and ecological influencing factors have been re-associated to morphology. This demonstrates how urban construction, alternation and the principles of their changes in low-lying waterfront areas interact with varying environmental factors. The paper first describes the mechanism of morphological adaptation to the environment in the study of the Duotian settlements, and then analyzes its plan morphological elements and their associated factors.

Background

The Lixiahe Region is a low-lying wetland located between the Huaiyang Section of the Grand Canal and the Yellow Sea, at an elevation that is generally lower than 5 meters. Due to changes in the historical hydrological environment and artificial water conservancy intervention, this region receives excess water and sand from upstream, gradually changing from a vast lagoon into a wetland with a dense network of rivers and lakes (Wu, 1996) (Figure 3). The previous water areas have been steadily developed and utilised by people, forming new settlements and production space.

Since Lixiahe Region is shaped like a pot with a higher elevation in the surrounding area and lower elevation in the middle, its ground level is gradually reduced from 5 meters in the surrounding area to approximately 1 meter. The lowest area of this pot-shaped region is the hinterland with the densest lakes and rivers. The large quantity of water facilitated transportation, which resulted in the development of some crucial towns and central cities mainly based on trade (Xu, 2016). The hinterland is also a belt on which a large scale of Duotian has been developed. Due to the unfavourable water environment but satisfactory trading conditions, the Duotian settlement system, which primarily cultivates vegetables, is constantly adapted and optimised, becoming a typical human waterfront settlement with ecological wisdom.

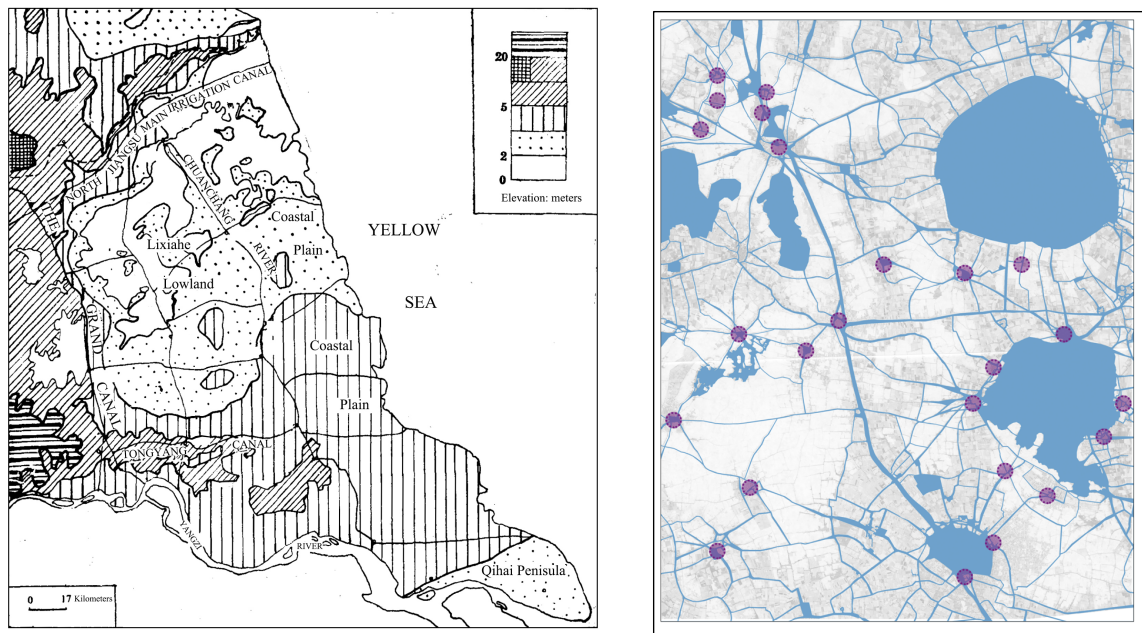


Figure 3. The elevation shows that the Lixia River area is located in the lowlands of the North Jiangsu Plain. Based on the map in 'A Study in Geographic System of the Historical Northern Jiangsu Plain uotian in Lixiahe region' by Bihu Wu .
Figure 4. The water environment and the distribution of Duotian settlements in the hinterland of the Lixiahe region.

Methodology

The report in this paper is mainly based on an analysis of maps. There are 3 categories of maps with varying levels of accuracy, thereby yielding different data. The first category is the maps in ancient local chorography of the counties in the Lixiahe Region which provide an overview of the historical-geographical environment, including the water and land interrelation and their orientation. The second category is the 1:50000 military maps drawn by the Japanese army in the 1920s. These maps provide the earliest detailed record of the terrain, with markings of the distribution of settlements and water transport lines. The third category is the modern electronic maps which provide essential information such as strict and accurate values, hydrological data and elevation.

Furthermore, the aerial photos taken by United States Geological Survey (UCGS) in 1970 reflect a more complete picture of the environmental conditions and a clear texture of landscape. It provides important

data for studying the distribution and morphological patterns of Duotian. Besides, the research also involves a field survey of Duotian, anthropological interview and collection of historical records (including agricultural and hydrological documents).

Traditional Duotian settlement system

Due to the low terrain and alternation of floods and droughts, it is difficult to manage water stably and built hydrological infrastructures in the hinterland of Lixiahe region. It resulting in the separation of the Duotian settlements by water and being independent of each other, building a completely self-sufficient system. This system can be deemed as an archipelago consisting of islands for living and production (Figure 4). For the convenience of description, the term settlement refers explicitly to islands used for inhabitation, and the term “Duotian” refers to islands used for production. The resilience to disasters and productivity of the system are dependent on the form, configuration and constitution of islands.

Settlements are often located beside lakes or at intersections of rivers because as early inhabitants selected places with higher terrain for building houses to avoid floods and ensure the stable water supply of Duotian . Duotian consists of variously shaped islands that were piled up by residents with mud from digging ditches in the marsh. With an increase in population, adjacent Duotian was combined to form new habitat while Duotian was further expanded.

The section of Duotian is trapezoidal and its slops are also available for planting. The height of the islands depends on the maximum flood level. It usually exceeds an elevation of 3 metres above water level to minimise the harm to crops. The ditches in Duotian are simultaneously adapted to drought conditions as they exceed a depth of 2 metres to allow for irrigation and navigability. After the 1950s, with the improvement of hydrological facilities, water has been effectively managed. With the stability of the water environment, Duotian also became lower and broader (Figure 5).

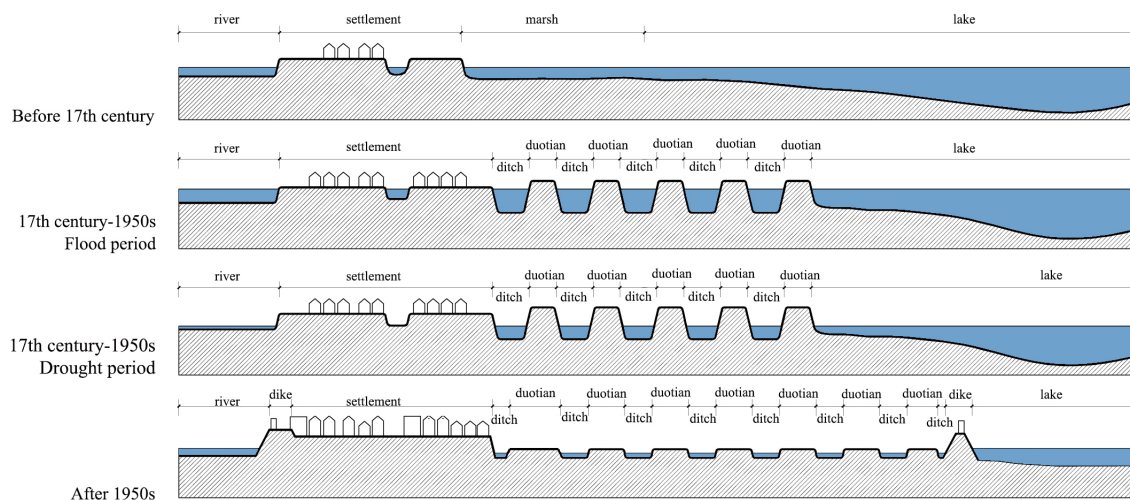


Figure 5. The water environment and the distribution of Duotian settlements in the hinterland of the Lixiahe region.

Morphological Elements of Duotian Plan

This paper describes the morphological elements of the Duotian plan by setting Dongwang village as a case. Dongwang Village is located beside Pingwang Lake, a lake connecting the busiest North-to-South Xiaguan River. In the 1970s, Dongwang Village built their own dikes, creating a physical isolating boundary. In this process, the village renovated its existing Duotian and developed new settlements and Duotian islands. With the advent of tourism, Duotian has been well protected during the large-scale alternation of farmland, providing a relatively wholesome sample.

Similar to settlements and buildings, Duotian is essentially an artifact elaborately built with soil—a three-dimensional space closely related to human’s behaviour. Therefore, Duotian is also a part of built environment, or namely, “an enormous set of indices arising from human activity” (Kropf, 2013). However, it differs from the urban environment mainly shaped by society. Primarily, Duotian should be obey the powerful control of nature. It changes fast, and there is a lack of historical maps or data records. Therefore, some aspects concerning the forms of Duotian cannot be directly identified from the present result. Instead, they could be identified indirectly after translation by incorporating them into the natural process.

The method adopted in the description of Duotian plan reference to the framework in the Town plan analysis by M.R.G Conzen. Conzen describes the morphological elements of two plan as streets, plots and bottom plane of buildings (Conzen, 1960). The three elements are combined in different ways to form various types of planes in other town areas. Based on the characteristics of Duotian, a similar description framework may also be established for its forms:(i) rivers and their arrangement in a river-system; (ii) ownership parcels and their aggregation in plot divided by rivers; (iii) Duotian islands. At the same time, the three elements also lie in a nested hierarchy: rivers are in the largest first layer; ownership parcels are in the medium layer; islands are in the smallest third layer (Figure 6).



Figure 6. Three elements of Duotian plan in Dongwang village which based on the analysis by Conzen's method.

The rivers in the first layer should be first distinguished from ditches, although both are water bodies bordering the islands. In terms of both irrigation and transportation of Duotian, rivers are arterial while ditches branch from those arteries. By digging several rivers perpendicular to lakes in marsh, water is introduced for connecting the arterial rivers and ditches. Therefore, the width of rivers is related to the irrigation area to be covered. On the other hand, Duotian and settlements are also a sailing system. The rivers are an open space that allows any boats with different functions and sizes, such as boats used for daily labor, freight, passenger transportation, fishing, etc. When they are viewed separately from other elements of the Duotian plan, the arrangement of continuous and inter-dependent space in the natural area may be labelled as a river system.

The ownership parcels in the second layer are a relatively critical element of Duotian plan forms. They are in the middle of the nested system and a key element connecting the whole framework. In essence, each parcel is a water and soil utilisation unit whose geometrical characteristics determine the digging of internal ditches and the means of soil accumulation. The physical boundary of a parcel is a ditch or a river, but not all ditches are such boundaries. All islands are fragmented without geometric shapes which can be easily described, while the texture of ditches is too complex to provide any clues; on the other hand, Duotian had undergone several land systems (including the landlord-ownership system in feudal society, people's commune and household contract responsibility system, etc.). Since land ownership had constantly been changing, it was challenging to identify stable social factors in the division of parcels. Therefore, the identification of the ownership parcel is mainly based on man's biological characteristics. These characteristics offer stable principles: 1) "maximisation of man's potential contacts with the elements of nature"; 2) "Minimisation of the effort required for the achievement of man's actual and potential contacts" (Doxiadis, 1970). Following evolving principles, the rule in the division of parcels is identified: 1) The connectivity of ditches is inversely proportional to the boat-reliant labour. Therefore, the ditches within each parcel are optimised through turns and inter-connectivity and form cells with benchmark ditches; 2) the land area is maximised without affecting irrigation and islands of each parcel are reduced as far as possible to allow maximum utilisation of boundaries, with only the open frontier of datum ditches. Figure 7 sorted the prototypes of parcels, each of which has its own suitable geometrical range and hydrological environment, coupled with an inter-combined structure. This part will not be discussed herein.

Figure7. The prototypes of ownership parcels in Duotian system.

Parcel prototype		Ditch topological form	island topological form	Transformation			Legend
One datum ditch	A1						<p> Tier I ditches (datum ditches) Tier II ditches Tier III ditches Tier IV ditches Hierarical constitution Duotian islands And so on. </p>
	A2						
	A3						
	A4						
	A5						
	A6						
	A7						
	A8						
Two datum ditches in same hierarchy	B1						
	B2						
	B3						
Two datum ditches in different hierarchy	C1						
	C2						
	C3						
	C4						
	C5						
	C6						
Others							

The elements in the third levels are islands. They are the necessary elements of the Duotian plan. The width of each island is generally 10-12 meters, which is jointly determined by biomechanical properties of human ability and tool capabilities. Duotian is mainly used for agriculture requiring frequent irrigation and fertilisation. However, these activities are done standing on the boat without actually setting foot on the islands. Therefore, the Duotian width is an optimised result through a long-term of human adaptation to the environment. Within each parcel, the distance between islands (width of ditches) is between 4 and 6 meters. This is determined by the size of labor boats, and such width allows two boats to sail in parallel routes and provides an adequate turning radius. Therefore, it is possible to obtain the basic modulus of Duotian and to use it in the morphological analysis.

Conclusions

Through a case analysis of Duotian settlements, a description is made on the objects in an established environment, rarely discussed in urban morphology. Such objects are considered as a natural landscape or an external environment of cities due to their proximity to natural attributes, resulting an ambiguous discussion. The research concluded that the morphological analysis of Duotian would aid in the development of unified spatial morphology for an ecological-social system. Such efforts are of considerable significance to waterfront habitat and SDG₁₁.

In conclusion, this paper addresses the importance of expanding the research objectives in built environment. It also proposes the possible analysis concerning the correlation between urban forms and multi-dimensional factors (including ecological, social factors and human action). This is helpful for an open multi-discipline engagement network available to researchers and practitioners.

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