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# Spatial characteristics and construction logic of traditional market under land-water transportation influences

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The spatial evolution mechanism of traditional market settlements under the influence of land and water transportation facilities profoundly reflects the dynamic relationship between regional social and economic development and the natural environment. This paper focuses on the market settlement system in the Dongguan region of the Pearl River Delta from 1840 to 1949. By integrating the methods of historical geography, architecture, and anthropology, using GIS spatial analysis, historical map registration, and field investigation, the paper systematically analyzes the spatial characteristics and construction logic of settlements under the influence of land and water complex transportation facilities. The results show that the settlements in Dongguan Market present a heterogeneous spatial distribution pattern, which can be divided into three spatial types: the strip type extending linearly along the water system, the block type dominated by clan power, and the Concave-convex derived from the expansion of the traffic network. On the micro-scale, the spatial organization of streets and lanes forms the topology of the radiation-type, the fish-ridge-type, and the grid-type, revealing the construction wisdom of the synergistic effect of the natural environment, clan governance, and transportation economy. This study provides historical and theoretical support for the protection of traditional settlements. It proposes to build a sustainable path for the coordinated development of the historical environment and modern functions through the linkage development of transportation heritage, the transformation of clan cultural capital, and the application of digital twin technology.

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## Introduction

**Research background.** As an important carrier for the evolution of human civilization, the spatial form and construction logic of traditional settlements profoundly reflect the social structure, economic model, and cultural tradition of a specific historical stage (Chen, Xie and Li, 2020). Such settlement not only has the material value in architecture and geography (Rowe and Chung, 2024) but also embodies the local knowledge system and collective memory, thus becoming a key entry point for the study of regional social changes. In 2012, China issued the Guiding Opinions on Strengthening the Protection and Development of Traditional Settlements, signifying the transformation of traditional settlement protection from scattered cases to systematic practice. Currently, it has established the world's largest farming cultural heritage system encompassing 8455 national and 5028 provincial protected lists (Ma, Zhang and Huang, 2023). However, in the cause of rapid urbanization, traditional settlements encounter multiple challenges: the existing social production network tends to collapse due to population loss and resource outflow, leading to spatial dysfunction. Extensive tourism development and disorderly construction further cut the context of settlement history, causing them to fall into the paradox of "protective destruction" (Wang, Zhu, Zhao and Lv, 2021; Zhong, 2021). In this context, how to disclose the endogenous mechanism of settlement spatial evolution through historical research, and then provide theoretical support for conservation planning has become the focus of the academic and design practice circles.

As a special type of traditional settlement in the Lingnan area, market settlements form a unique spatial organization pattern based on periodic commodity trading activities, and their rise and fall trajectory is closely associated with the evolution of the regional transportation network (Yin and Feng, 2024). Since modern times (1840–1949), the modernization of land and water transportation facilities reconstructed the economic and geographical pattern of the Pearl River Delta. The construction of ports, railways, and highways not only accelerated the efficiency of commodity circulation but also gave rise to different spatial types through the interaction mechanism between traffic and settlements (Liang, 1982). The market settlements represented by Dongguan are located at the core of the trade corridor between Guangzhou and Hong Kong, and their spatial structure demonstrates the characteristics of linear distribution along the water system to the expansion of the land transportation network expansion. Although existing conservation practices have focused on the restoration of single buildings in the market (Wang, Zhang and Wu, 2022), they generally overlook the shaping effect of transportation infrastructure on the overall spatial logic of settlements, resulting in a disconnect between conservation strategies and historical stratification. Therefore, the systematic analysis of the spatial characteristics and construction logic of the settlements in the market under the influence of land and water traffic is not only an important path to improve the study of traditional settlement typology but also provides a historical methodological reference for solving the realistic contradiction between protection and development.

**Literature review.** After multi-disciplinary exploration, the research of market settlements has formed a multi-dimensional theoretical framework. The early research can be traced back to the central place theory proposed by Walter Christaller and August Losch. Their market area model reveals the intrinsic relationship between settlement level and transportation cost. Providing a classical paradigm for understanding the spatial distribution of the market (Christaller, 1980; Losch, 1962). In subsequent studies, Walter Isard's location theory pointed out the

restructuring effect of transportation facilities on the market radiation range, developed a heterogeneous spatial model, and emphasized the influence of terrain barriers and resource endowment differences on the spatial level of settlements (Isard, 1956). Although these theories originated from the study of the Western urban system, they are instructive to the analysis of the market network in the Pearl River Delta. G. William Skinner proposed the macroregional theory based on the case of the Sichuan Basin in China (Skinner, 1995) and localized the central place model. However, the applicability of his "hexagonal" market model was limited in the Pearl River Delta environment. Empirical studies in Taiwan, Jiangnan, Shandong, Zhili, and other regions have revealed the deficiency of this theory in explaining spatial distribution characteristics (Hu and Xu, 2012; Meng and Pei, 2020; Hu and Lu, 2012; Shao, 2020).

The research concerning the correlation between transportation infrastructure and the market has drawn extensive attention. Railway and shipping facilities can reshape the hierarchical system of the market by reconstructing the flow path of factors (Tang, 2021; Zhan, 2017; Liu, 2015). An empirical study of market cities in North China reveals that railway plays a screening role in regional economic vitality (Xiong, 2017). However, most of these studies focus on the discussion of a single traffic mode and generally show the tendency of environmental determinism and lack of explanation for the socio-economic causes of the survival of the market along the traffic route. Focusing on the research of market settlements in the Dongguan area, the reason and dominant factor for the continuous expansion of the scale of Dongguan Market is the outcome of the joint effect of economic factors, population development, natural conditions, and traffic factors (Wu, 2014). Market settlements can be classified into civil and official markets, comprehensive and professional markets, flat and mountain markets, coastal and inland markets, etc. (Tang, 2013). From the perspective of commercial research, the interface features, scale proportions, and spatial nodes of street space can reflect the typical characteristics of settlement spatial form (Zeng and Jiang, 2021). At the same time, Lingnan farming culture has a profound influence on the settlement space. Chashan Market possesses certain features in terms of spatial scale, street texture, and architectural form (Ye, 2018). Some scholars also described the environmental conditions, agricultural economy, and the development of the silk industry in South China from the perspective of spatial narrative (Marks, 1998), and expounded the social status, economic activities, ethnic relationships, and their role and influence in social reform of gentry and merchants in Guangdong (Qiu, 2012). However, the integration of existing research theories is inadequate. The relationship between infrastructure and market settlements is often divided into a single subject, concentrating on the simple description of the social system, transportation construction, or economic function. The systematic analysis of the physical spatial form still requires further deepening, especially the deficiency of the spatial coupling mechanism between water and land transportation facilities and market settlements in Dongguan. The spatial characteristics and construction logic of market settlements are discussed in depth.

From a methodological perspective, the existing studies employed GIS spatial analysis to disclose the overall spatial distribution of the Pearl River Delta market in the Qing Dynasty (Chen, Liu, Wu, and Liu, 2021). However, over-reliance on statistical models resulted in the simplification of the social process of spatial production. The approach of restoring the social network of the market through local Chronicles and oral history (Wu, 2014) frequently lacks a visual description of the spatial morphology. Given this, this study integrates the perspectives of

architecture, sociology, and historical anthropology, ranging from macro-regional spatial distribution to micro street mechanism, to conduct a multi-dimensional analysis of traffic facilities and spatial characteristics of market settlements, with the aim of breaking through the single-dimensional limitations of traditional methodology and filling the reach gap on Dongguan market settlements.

**Problem statement and objectives.** Literature studies have shown that as a special type of commercial space carrier, the evolution mechanism of the spatial form of traditional market settlements has significant characteristics of traffic dependence (Tang, 2021; Xiong, 2017). Nevertheless, current research paradigms mainly concentrate on the linear influence of a single traffic mode on the market distribution and lack of investigation into the synergistic effect of land and water complex transportation systems. In particular, the mechanism of the reconstruction of the land and water transport system in the modern Pearl River Delta on the remodeling of the market settlement space, remains unclear. Regarding the theoretical framework, existing studies tend to separate the material and social attributes of traffic facilities. Case studies in Dongguan mostly focus on the description of single settlements and have not yet formed a typological system covering the county scale, and lack visual analysis of micro-spatial elements such as street organization (Tang, 2013). Therefore, the core proposition of this paper centers on the spatial response mechanism and adaptive construction patterns of modern traffic facilities and market settlements, establishes the spatial classification system of Dongguan market settlements, analyzes the differentiated characteristics of settlement forms under different traffic location conditions, and interprets the construction wisdom and logic of traditional human settlements through the deconstruction of street space of typical samples. To provide adaptive strategies for traditional settlement protection.

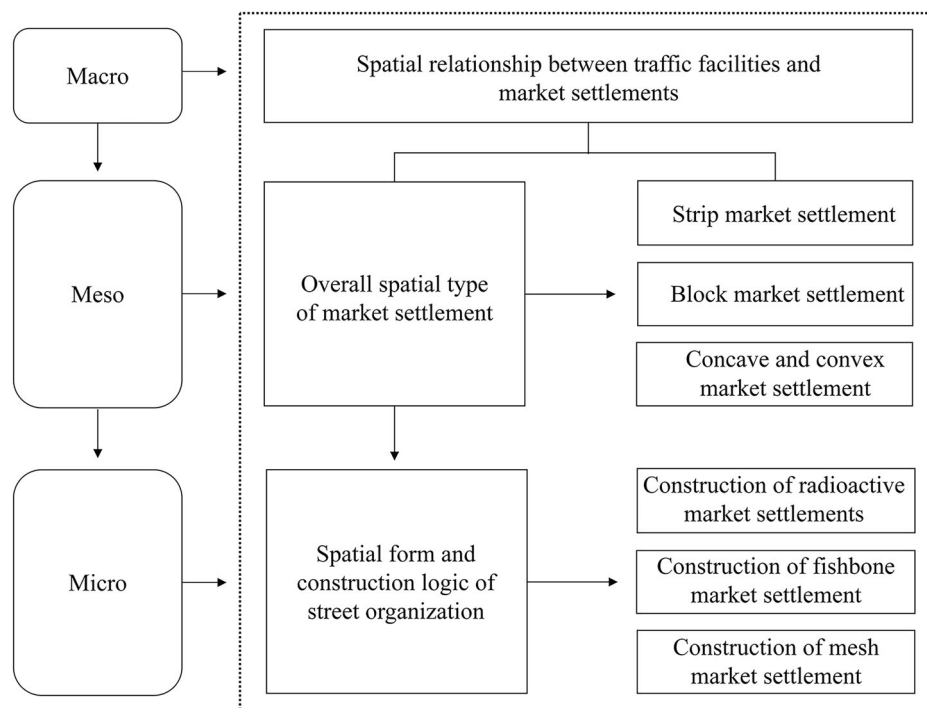
The structure of this paper is as follows: The second part elaborates on the research methods and objects in detail and

clarifies the spatial relationship between water and land facilities and market settlements. The third part explains the overall spatial type of the market settlement. The fourth part analyzes the spatial form and construction logic of the settlement street organization in the market. The fifth part summarizes the research results, makes a comparison with the existing research, and puts forward the research focus, shortcomings, and future research direction of this paper.

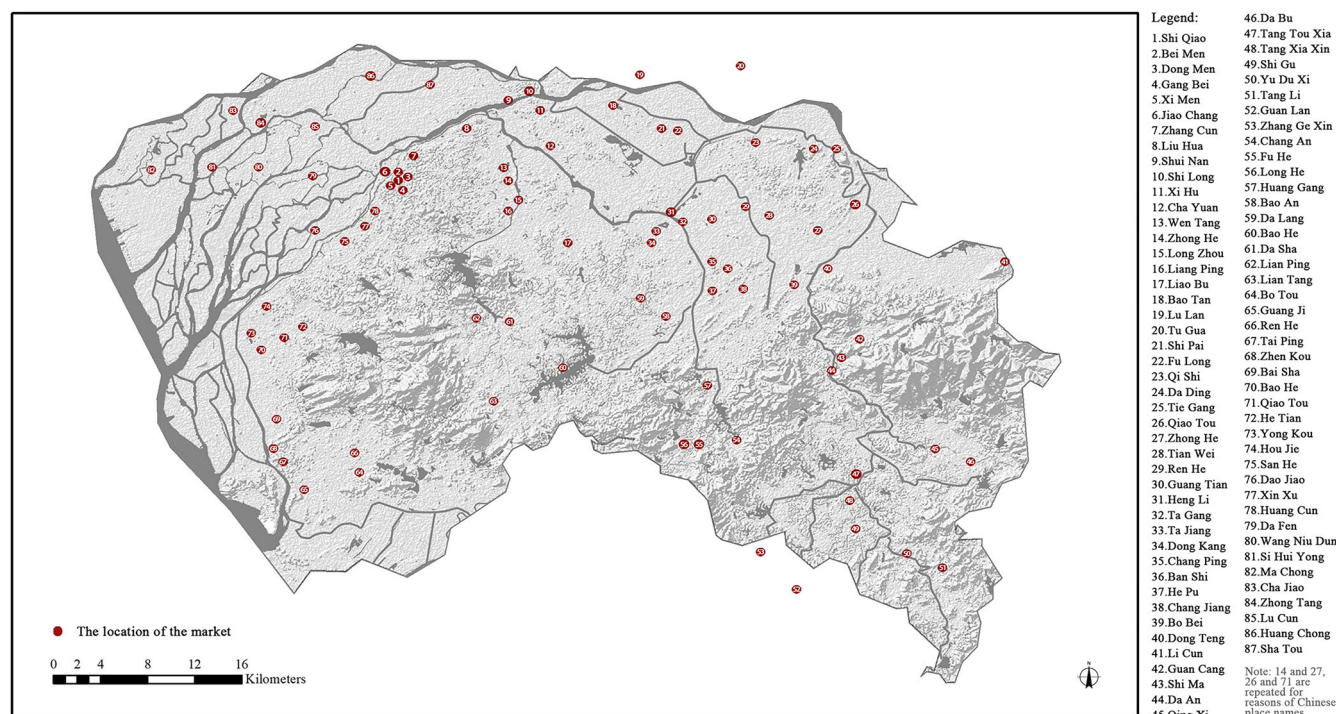
## Research methods and objects

**Research methods.** This paper explores the spatial characteristics and construction logic of traditional market settlements influenced by land and water transportation facilities from macroscopic, mesoscopic, and microscopic perspectives (Fig. 1), with the aim of conducting a multidimensional analysis of the spatial characteristics of traditional market settlements through field investigation, cartography, historical and archival research methods.

1. Spatial data correction and geographic registration: Historical maps, local records, and satellite image data, complete geometric correction through control point registration to eliminate projection distortion and scale differences. The ArcGIS platform was employed to superimpose modern road networks and hydrological layers to locate the spatial points of traffic and market settlements recorded in the local Chronicles and cross-verify them with the location features in satellite images. Given the deviation between the historical map and the field, the authenticity of the space is determined by integrating the hydrological report, historical description, and field survey.
2. Historical context reconstruction and data triangulation: The name of the market is extracted through local Chronicles text mining, and the information gaps are filled with folk documents such as inscriptions and genealogies. During the field investigation, typical sample sites were selected. The street texture was recorded through participatory observation, and oral historical materials were



**Fig. 1** Research framework (Source: Self-drawn).



**Fig. 2** The location of the market settlement (Source: Self-drawn).

obtained via semi-structured interviews. Architectural surveying and mapping data were drawn by CAD, compared with historical pictures, and the evolution of architectural shape and system was discriminated.

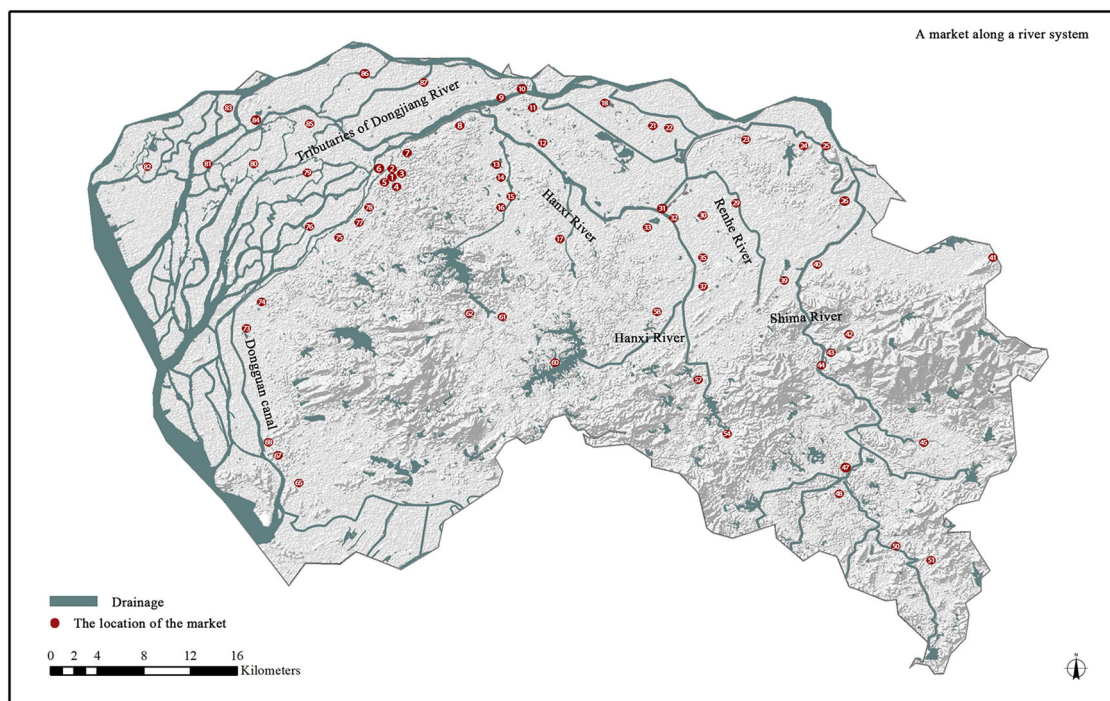
**Data sources.** The image data in this paper originates from the website of the United States Geological Survey (USGS), which provides a base map for the spatial identification of the settlement and the analysis of the street texture. Regarding the archival data, over 20 volumes of local histories, including Dongguan County Records, Guangzhou Prefecture Records, and Guangdong New Words, are acquired from the Anna Digital Archives Platform (<https://annas-archive.org/>), from which the structured information of marketplace settlements, transport facilities, and clan societies is extracted. In addition, the 1932 survey map of the Guangdong Geological Survey Bureau in the collection of the Guangzhou Municipal Library and the accompanying maps in the Dongguan County Record of the Republic of China serve as the important bases for the historical map study in this paper. The spatialized integration of multi-source data and the in-depth mining of text provide solid historical support for uncovering the association between transport facilities and settlement space.

However, research into the spatial accuracy of historical maps has inevitable limitations, which are caused by previous measurement techniques and temporal differences. These limitations may affect the interpretation of settlement locations and spatial relationships. To mitigate their impacts, the study cross-validated the accuracy of the data through methods such as integrating hydrological reports, historical data descriptions, and field investigations, to ensure that the core issues discussed in this paper remain valid.

**Research object.** The Pearl River Delta market settlement system gradually took shape during the prosperity of the commodity economy in the Ming and Qing dynasties, and its spatial evolution was deeply coupled with the specialization process of the

regional trade system. In the modern era (1840–1949), under the dual influences of the reconstruction of the geopolitical pattern and the innovation of transportation technology, the region witnessed a transformation from a traditional town to a modern business hub. With the First Opium War as a turning point, the trade system of the Pearl River Delta underwent structural adjustment, and the rise of Hong Kong's trade status facilitated Dongguan to become a regional commodity distribution center (Situ, 1990). Taking Dongguan County as the spatial carrier, this paper focuses on the drastic social transformation period from 1840 to 1949. The spatial data were superimposed with the county map attached to the County Annals of Dongguan in the Republic of China and the contemporary administrative divisions, and the geographical locations of 87 markets were verified and determined through topological relationship (Fig. 2). In addition, the study selects a market settlement with cultural heritage attributes and elaborates on the spatial form and construction logic of its street organization in detail, which serves as an important empirical basis for interpreting the market spatial paradigm.

Dongguan is situated in the east wing of the Pearl River Delta. The terrain slopes from southeast to northwest, and its main water systems consist of the main stream of the Dongjiang River, the Shima River, and the Hanxi River. Affected by the subtropical monsoon climate, the rainfall in the region was abundant and concentrated. From 1796 to 1949, 137 floods occurred in the Pearl River Delta, with an average of one flood every 1.2 years (Water Resources Bureau of Dongguan City, Guangdong Province (1990)). To cope with the threat of flood, dikes were constructed to surround water conservancy facilities along the mainstream of the Dongjiang River in the Song and Yuan Dynasties, and a flood control system with a total length of 38,000 zhang (a traditional Chinese unit of length, where 1 zhang is about 3.33 meters) was formed by the end of the Qing Dynasty (Zhao and Yang, 2011). Such projects not only guarantee agricultural production but also expand the development of settlement space through land reclamation. The “Twelve Square”



**Fig. 3** Market settlements adjacent to water systems (Source: Self-drawn).

in the Guancheng Market is a business center gradually formed by relying on the dike system of the south branch of the Dongjiang River (Wu, 2014). During the Yuan Dynasty, the port trade of Quanzhou was extended to Dongguan via water transportation. This promoted the rise of coastal markets such as Humen and Shilong, and established commercial ties with Iran through the “Maritime Silk Road”. (Situ, 1990). In addition, in the Qing Dynasty, Shilong Market beside the main stream of the Dongjiang River was surrounded by water on three sides and became a distribution center for bulk commodities such as timber and grain (People’s Government of Shilong Town, Dongguan City (2004)). Dongguan formed a transportation hub city centered on Guancheng, Taiping, and Shilong, as well as a coastal zone of water system and port. Due to the frequent agricultural activities facilitated by transportation, the commercialization process of agricultural products was promoted, and the area has gradually become a concentrated area of commerce and population, confirming the spatial logic of “thriving the city with water” (Fig. 3).

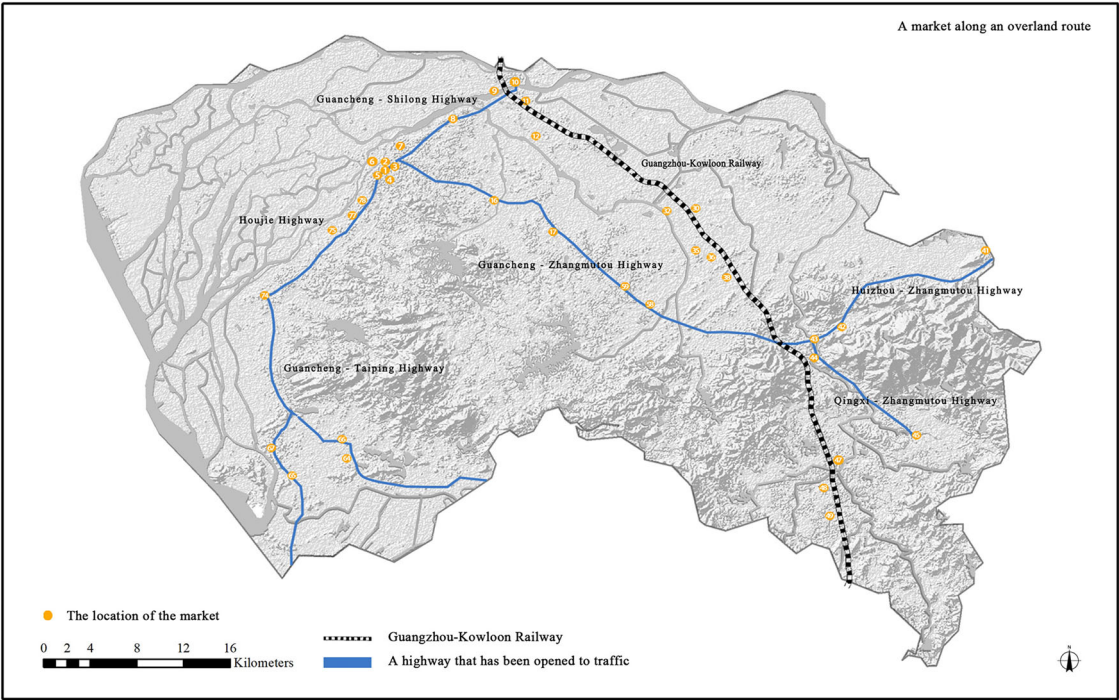
During the Republic of China era, large-scale construction of roads, bridges, and railways in Dongguan supplemented the development of market cities in inland mountainous and plain areas lacking water routes (Fig. 4). From 1929 to 1938, Dongguan initiated the construction of the Huizhang Highway, Guanlong Highway, Guantai Highway, and other significant roads, initially forming a regional road traffic network. (Editorial Committee of Dongguan Traffic Annals, 2010). Modern transportation facilities have overcome the limitations of water systems. Due to the establishment of the Guanzhang highway and train station, the number of shops in Changping Market has increased by more than 100, transforming it from a traditional agricultural market City to a regional business transit station (Editorial Committee of Changping Town Annals, Dongguan City, 2009). The Guangzhou-Kowloon Railway, stretching from Guangzhou to Hong Kong, passes areas such as Shilong, Chashan, Hengli, Changping, Zhangmutou, Tangxia, Fenggang, and others in Dongguan. This has brought significant changes to the spatial level of the market along the line. Bobei Market, Renhe Market,

Hepu Market, Changjiang Market, Banshi Market, Songjiang Market, Hengli Old Market, and other places have witnessed decline and even extinction due to the establishment of train stations (Editorial Committee of Hengli Town Annals, Dongguan City, 2010; Editorial Committee of Changping Town Annals, Dongguan City, 2009).

### The overall spatial type of market settlements

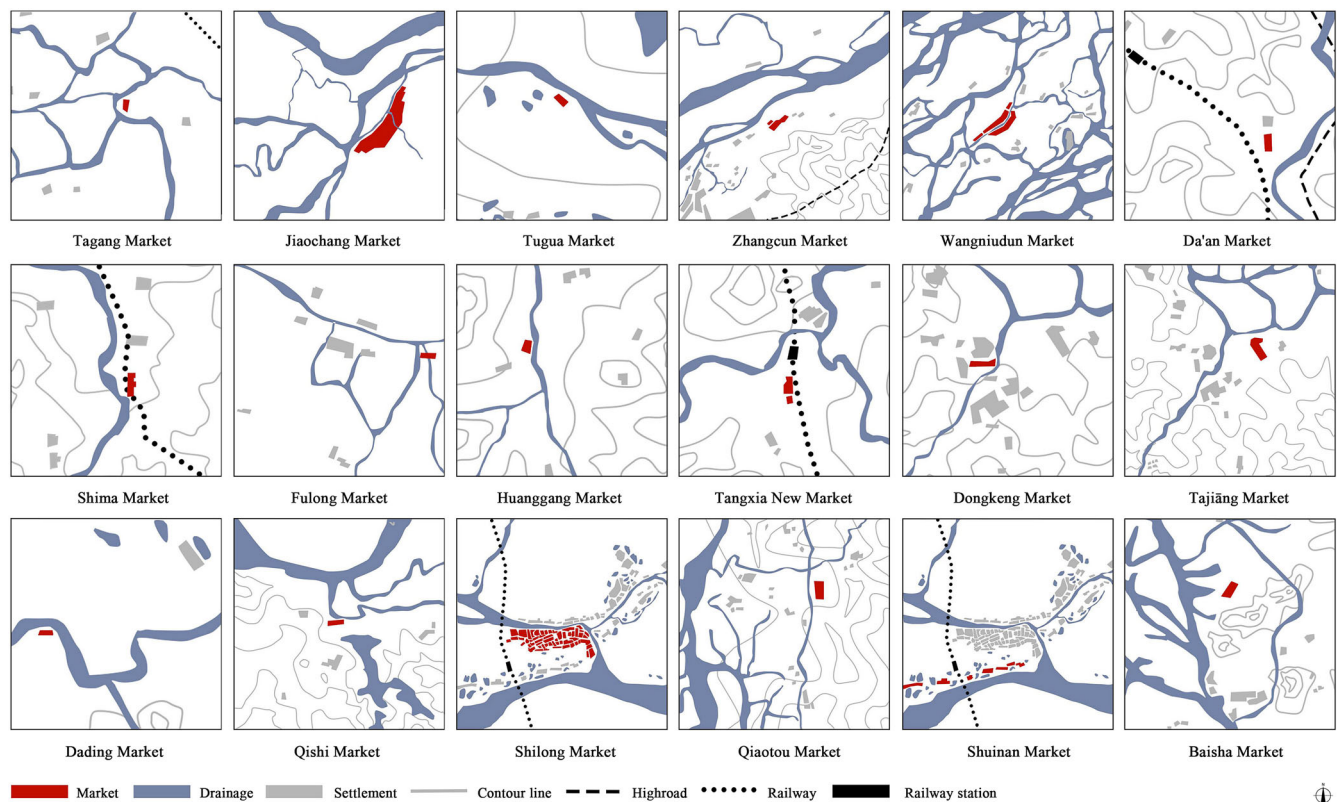
Settlement space emerges as the outcome of the synergistic effect of the natural environment, traffic network, and social and cultural elements (Tao, Chen and Xiao, 2017; Xian, Ran and Di, 2022; Vasconcelos et al., (2025)). Based on the dual standard of morphological characteristics and functional attributes, this study classified the settlements in Dongguan Market into three types: strip type, block type, and Concave-convex by using CAD boundary recognition, local Chronicles, and field investigation (Luo, Huang and Huang, 2023). The proposed classification system originates from the spatial analysis of historical maps, which not only reflects the constraining effect of geographical elements but also discloses the impact of social organization on spatial form (Table 1).

**Strip-type of market settlement.** The main feature of strip-type market is that the boundary of settlements is narrow and long, mainly distributed in the areas along the gulf and rivers. Its essence is the product of the synergistic effect of water transport economy and trade (Fig. 5). The river width and shipping conditions of this kind of market directly determine the size of the market and the spatial scale of vertical extension. Shilong Market, Shuinan Market, and other places are distributed in a strip pattern along the mainstream of the Dongjiang River. Most of the shops form a typical pattern of “front shop and backport”. The first line of the river is the commodity trading area of grain and rice, and the second line of shops deals with daily groceries. This reflects the spatial stratification of the shipping-dependent economy (People’s Government of Shilong Town, Dongguan City (2004)). This linear layout is not merely a simple



**Fig. 4** Market settlements adjacent to roads and railways (Source: Self-drawn).

Table 1 Comparison of Characteristics of Spatial Types of Market Settlements (Source: Self-drawn).			
Feature dimension	Strip type	Block type	Concave-convex type
Traffic characteristics	Highly dependent on water transportation: Linearly distributed along riverbanks/bays, with docks being the core hubs; The market scale is restricted by the width of the river channel and shipping conditions. The layout is designed to maximize the efficiency of goods handling.	The combination of water and land, with a focus on internal transportation: The form is influenced by the requirements of geographical security and the integrity of the clan territory. The internal transportation lines connect the ancestral halls, markets, and residential areas, forming the internal network of the settlement. The external transportation points are under control.	Relying on the radial transportation network: expanding outward along important roads or rivers; The potential for multi-directional development can form a broader market circle. The transportation network is a key driving factor for the evolution of settlement patterns.
Boundary form	Narrow and long: The boundary conforms to the riverbank line or coastline, presenting obvious linear characteristics.	Regular geometric shapes: The boundaries are mostly rectangles, circles, or polygons; The form is stable, demonstrating a clear sense of defense or territory.	Irregular shape: The boundary is tortuous and extends in multiple directions; It is often composed of multiple markets. The outline reflects the competition for land rights or ecological adaptation.
Spatial order	Linear stratification: Form a clear spatial stratification along the traffic lines; Spatial organization serves the economic efficiency of shipping.	Centripetal hierarchy: With ancestral halls or temples as the core, a hierarchical spatial system such as “ancestral hall - market - neighborhood” is formed. The spatial structure reflects the power order and defense needs of the clan. The functional zoning is clear.	Multi-nucleated complex: It has strong spatial expansion directionality and often forms multiple secondary centers. The spatial boundaries and internal structures are jointly shaped by land ownership relations, transportation accessibility, and ecological adaptability, presenting complexity and adaptability.
Governance mechanism	Dock commercial guilds: The spatial order is shaped and solidified by the “dock culture” that pursues loading and unloading efficiency and specific commercial transaction models.	Clan power dominance: The spatial form is the result of spatial production dominated by clan power. Ancestral halls serve as spiritual and governance centers; Spatial structure serves clan governance, defense, and the maintenance of internal social order.	Multi-agent coordination & adaptive governance: Spatial form is the result of continuous coordination, adaptation, and adjustment of rural society under resource constraints; Governance involves the interaction and compromise of multiple actors.
Typical representative	Shilong Market、Shuinan Market	Guancheng Market、Chashan Market	Daojiao Market、Guancang Market



**Fig. 5** Strip type of market settlements (Source: Self-drawn).

geographical adaptation but also carries a specific commercial cultural logic. The pursuit of maximizing the efficiency of cargo handling gave rise to the dock culture characterized by “bamboo canopies in continuous lines and warehouses lined up in rows,” while the three—party transaction model of “merchant—middleman—boat owner” solidified the spatial order of the market settlement (Ye and Tan, 1984).

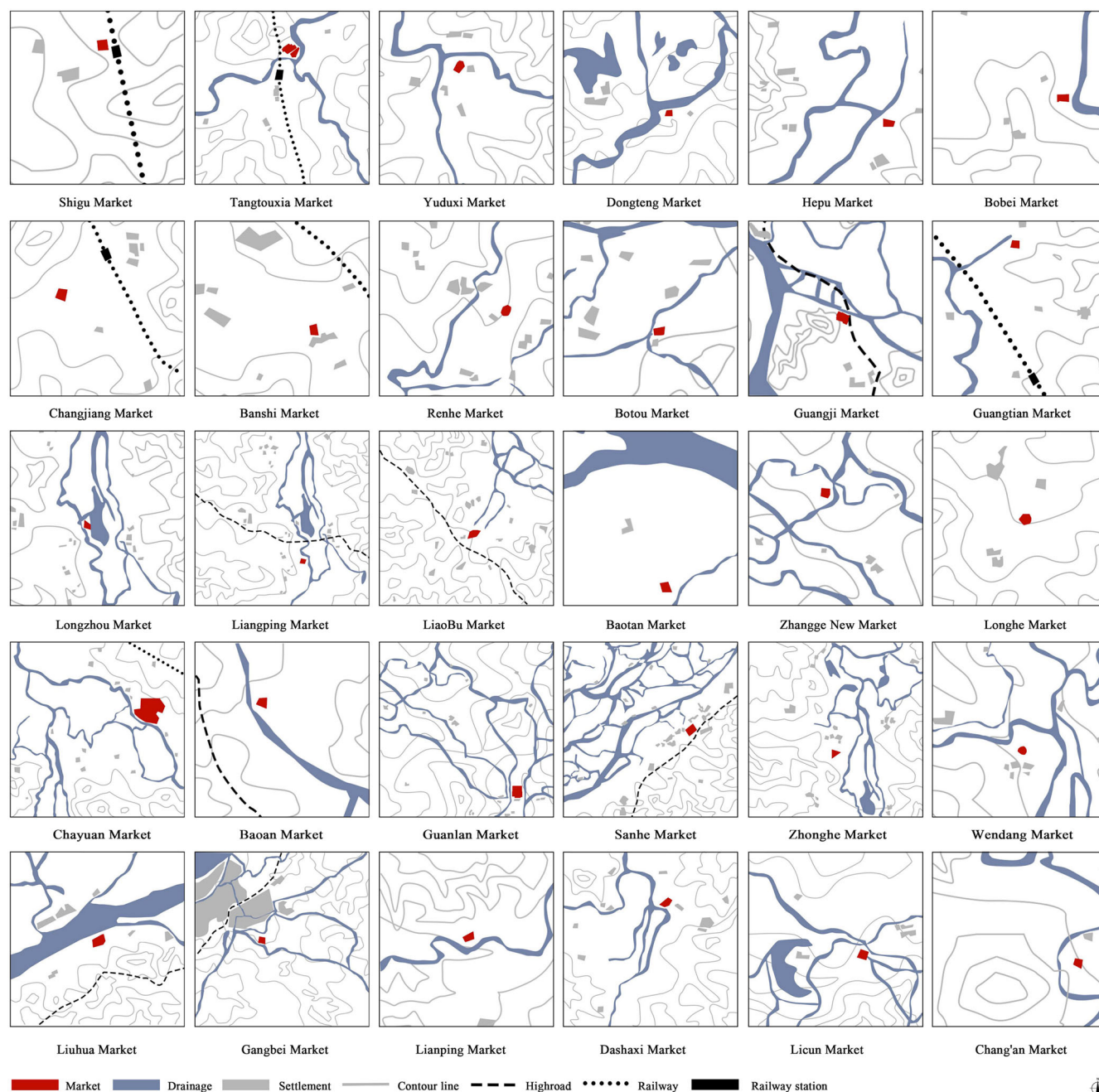
**Block-type market settlement.** The block-type market is the most common, featuring rectangular, circular, or polygonal borders. Its shape originates from the spatial production mechanism dominated by clan power and is also a strategic choice to evade flood risk and maintain the integrity of clan territory (Fig. 6). The spatial structure of Guancheng Market was initially based on the ancestral temples of the Yuan family, Deng Family, and He family, and commercial activities and clan governance were realized through the three-level spatial system of “ancestral temple—market—neighborhood”. On this basis, a large number of production and living functions were gathered and connected through internal transportation lines, forming a massive spatial form (Dongguan Guancheng Compilation Committee, 2011). Chashan Market have temples as the core, and the circular wall boundary reflects the characteristics of a military fortress. The city wall was constructed in the Ming Dynasty to defend against the chaos of Huang Xiaoyang forcibly integrated the living quarters of the Yuan, Lin, and Wei families, and formed a place for commodity trading along the Hanxi River inside and outside the city wall (Dongguan Chashan Town Compilation Committee, 2010). The stability of the block market is essentially a reflection of the traditional social order with clan power as the core in the spatial dimension (Liu, 1999).

**Concave-convex type of market settlements.** The edges of concave-convex type of market settlements are irregular and

spread in multiple directions (Fig. 7). Some large concave-convex type of market settlements often consist of multiple market combinations. The expansion of settlements is closely related to the transportation network. Many markets expand outward along important roads or rivers. Relying on the radial transportation system, market settlements can develop in all directions, thus forming a broader market circle. Meanwhile, the irregular space boundary also reflects the complex land right relationship and ecological adaptation wisdom. The concave-convex contour of Daojiao Market is influenced by the competition among the Chen, Liu, and Ye families for the control of land and river surges, which leads to the extension of the market boundary with the zigzag boundary piles to form a concave-convex boundary. The “convex part” is mostly the basement agricultural area, which can cushion the flood impact and supplement the market economy through pond fish trading (Dongguan Daojiao Town Annals Compilation Committee, 2010). Guancang Market was affected by Hui Zhang Road, which split the market settlement into two. The physical barrier effect of the road disrupted the original social network of the market but promoted the rise of shops along the road. The concave-convex type of market form is an adaptive spatial solution formed through continuous adjustment of rural society under resource constraints (Skinner, 1964).

### Spatial form and construction logic of street organization

In the process of transforming traditional market settlements into modern urban spaces, the structure of street and alley space serves as the path connecting commercial points. The expansion of street and alley space reflects the dynamic change of the spatial pattern of settlements, boosts the division of internal functional areas of settlements, and significantly promotes the agglomeration effect of economic activities. Meanwhile, street space is also the carrier of local culture and social life, carrying local memories and cultural traditions. Through the superposition analysis of



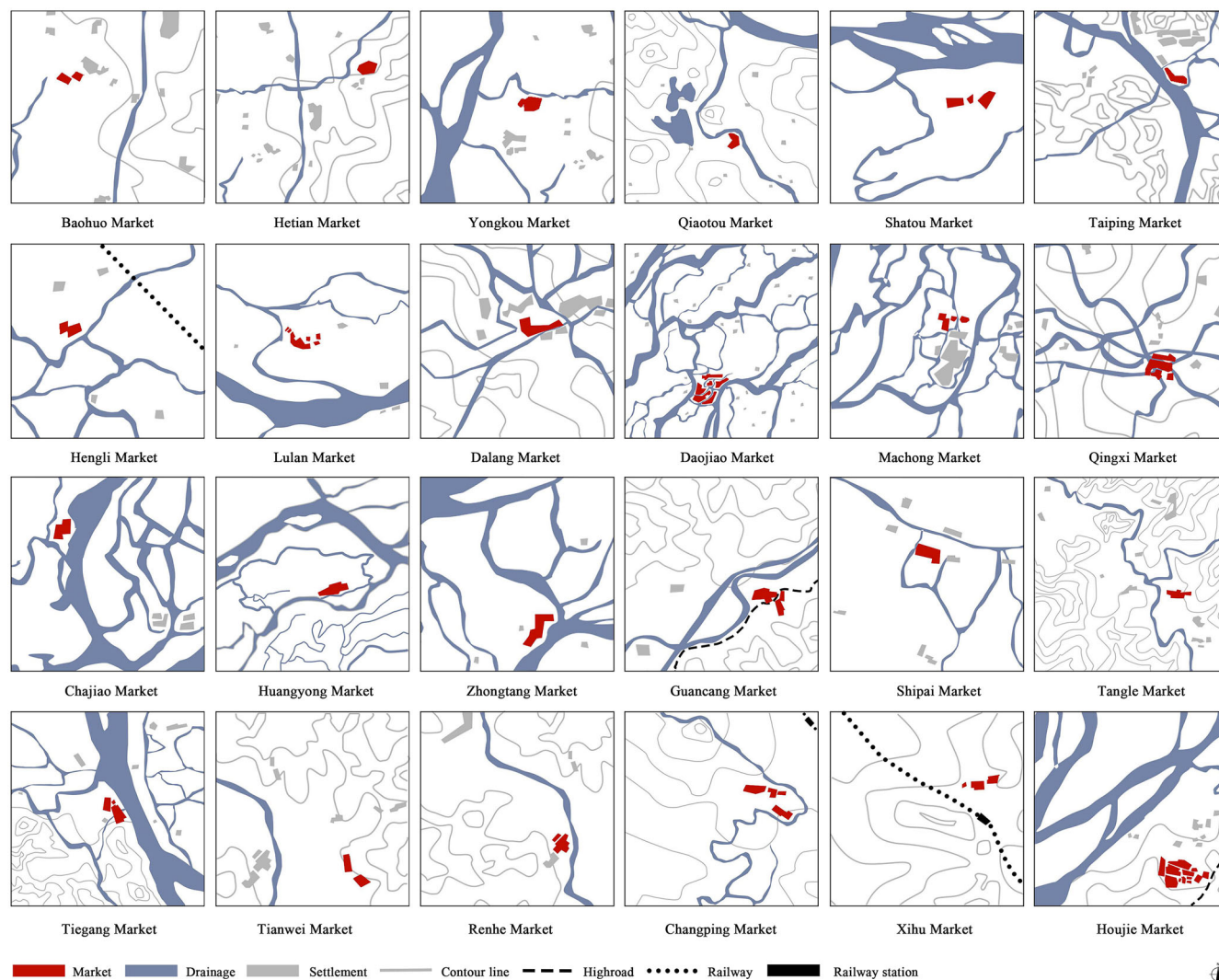
**Fig. 6** Block type of market settlements (Source: Self-drawn).

historical maps, remote sensing images, and architectural surveying and mapping data, this study summarized them into spatial forms of the radiation-type, the fish-ridge-type, and the grid-type, and selected typical market settlements such as Chashan Market, Shillong Market, and Guancheng Market for the case study.

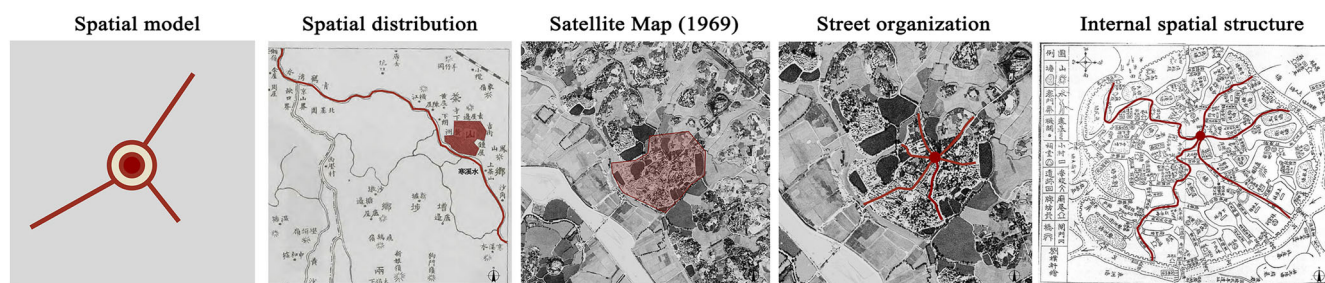
**Construction of radioactive settlement: Chashan Market.** As recorded in the Republican-era Gazetteer of Chashan, the Chashan Market derived its name from the fact that monks constructed Yanta Temple and planted tea in Tieluling over 500 years ago. Its settlement space depends on the water pond and hill landform, forming a radiation-type spatial pattern centered around the Shanggudi Temple. This kind of market layout with temples and ancestral halls as the core is not only restricted by the mountain direction but also sublimates the public space into a

spiritual landmark due to folk beliefs. The outward-radiating road system not only connected the clan settlements but also strengthened the cohesion of the settlements by concentrating trade and social functions, demonstrating the spatial wisdom of Lingnan farming settlements of “building according to the situation and gathering people by god” (Fig. 8).

**Landscape spatial pattern.** According to the Ancient and Modern records of Chashan, it is described as follows: “In the Southern Dynasty, the area was sparsely populated, and the Tanka people were seen on the river, living by the water, and the pottery fou was the instrument. Sui, Tang, and Five Dynasties, the common people gradually dispersed. Until the Song Dynasty, people from all over the world moved here.” It can be perceived that the villagers of Chashan Market are mainly Tanka, who originally concentrated in the estuary area and took fishing as their



**Fig. 7** Concave-convex type of market settlements (Source: Self-drawn).



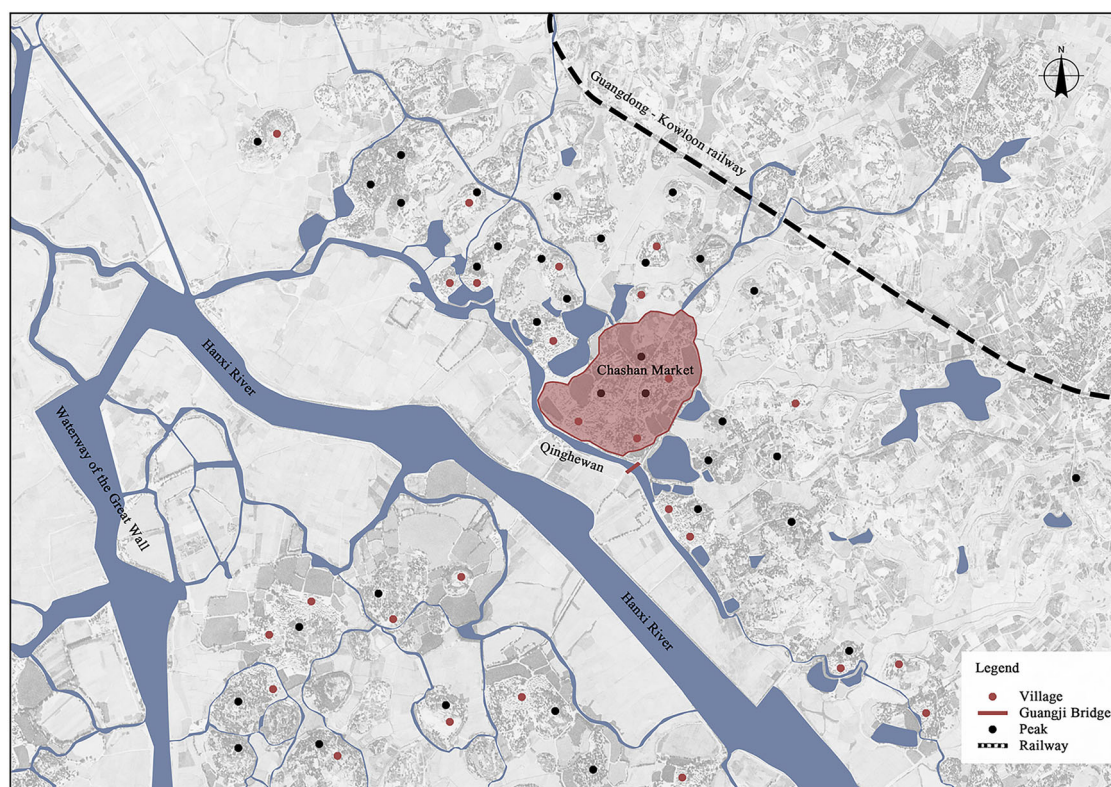
**Fig. 8** Chashan Market as a Radial Settlement (Source: Self-drawn).

business. Chashan Market is close to the Qinghewan water system, and its settlement layout follows the spatial pattern of “back mountain and face water”, which is conducive to agricultural production and water resource management, laying the foundation for commercial development.

Surrounding Chashan Market lies a strong city wall, which is approximately 1665 meters in total length. Considering the convenience of trade, there are four main city gates in the east, west, south, and north, along with three auxiliary gates (Dongguan Chashan Town Compilation Committee, 2010). Within the settlement, there are 3 hills, 7 ridges, and 18 fish ponds. The whole settlement is divided into 13 blocks, with stone

bridges and moats connecting the three main gates to the east, west, and south. Among them, the Guangji Bridge outside the south gate has become one of the most prosperous business districts due to its numerous piers on both sides (Fig. 9).

**Street topology.** The radial street system in Chashan Market shows a distinct centrality gradient. Within a 50-meter radius of the Shanggudi Temple as the core, Caishi Street, Shiwei Street, and other first-level streets, which are 4–6 meters wide, are paved with stone slabs and equipped with drainage culverts. Their spatial scale and construction specifications are significantly superior to those of other areas. These streets not only serve as the core areas



**Fig. 9** Geographical location of Chashan Market (Source: Self-drawn).

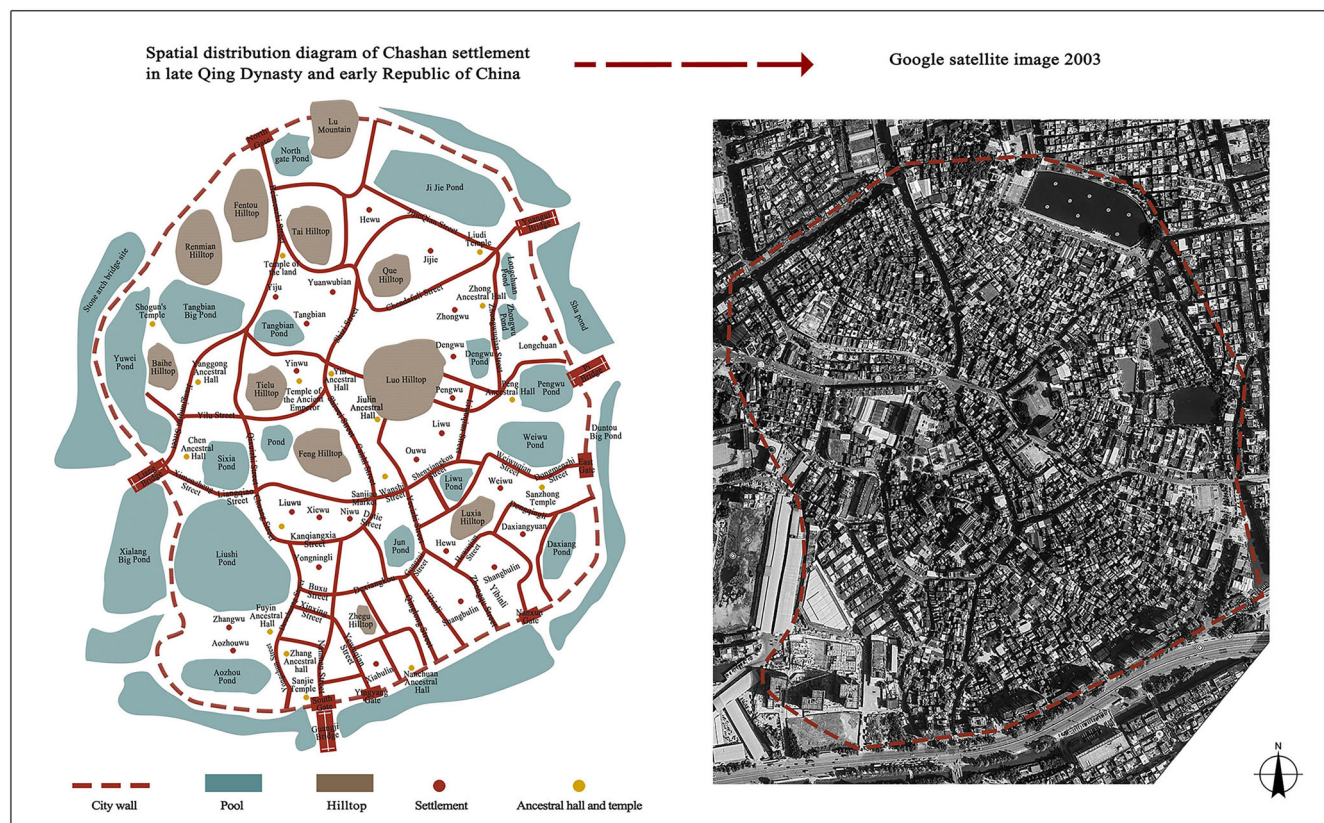
for business activities but also act as the central places for annual festival parades, clan sacrifices, and other ceremonial activities, representing the spiritual symbol of the settlement space (Dongguan Chashan Town Compilation Committee, 2010). The second level street extends to the clan-populated areas, with a width of 3–4 m to meet the needs of daily communication. The public facilities such as well and banyan trees, distributed along the street form secondary central nodes. The third-level roadway penetrates the residential cluster with a scale of 1.5–2 m and realizes the conversion of public and private fields through the transition of gatehouses. Among them, Triangle City is the most frequent location of economic activities in the settlement. On the southeast side of Luoshan, the fan-shaped spatial layout composed by Ou Wu, Wei Wu, He Wu, Li Wu, Peng Wu, Deng Wu, Zhong Wu, and other clan settlements has been preserved until now. The centrality gradient model of Chashan Market shows the spatial power structure of “core leadership - hierarchical penetration” in traditional society (Fig. 10).

**Architectural form and social space.** Chashan Markets settlement is built based on the principle of “back mountain and face water”, forming a spatial pattern of a “mountain-dwelling-pond”. According to the records of “Xiang Family Tree”, this place was jointly built by over ten family names such as Tao, Hong, Liu, and Lu. Each clan maintained blood relationships by developing residential areas, compiling genealogies, and building ancestral halls. Taking Lang Village as an example, its spatial texture demonstrates the building wisdom of multi-clan collaboration (Fig. 11). In the north of the village, the Tongshan Mountain serves as a barrier, the Yuan clan ancestral Hall is established in the south to emphasize the clan status, and the four-way village gates, walls, and towers constitute the defense system. The small ponds scattered around the first four villages imply traditional feng shui concepts. In 1737, to conform to the trend of the Tongshan Mountain and Qinghe Bay water system, the

residential houses on the west side were shifted 15 degrees to the east, and the Juyin ancestral hall was built on the west side. This adjustment not only ensures that the roadway texture fit with the landscape vein but also strengthens the spatial order through the axis control of the ancestral hall. In the late Qing Dynasty, the clan decided to connect the scattered small ponds into a large one, reflecting the feng shui pattern of “gathering water to generate wealth”. From the guard of the turret, the axis of the ancestral hall to the transformation of the pool, the architectural form has always served the power of the clan. Tongshan and the ancestral hall form the longitudinal spatial axis, while the pond and the roadway form the horizontal connection vein, jointly cast the multidimensional social spatial structure of “Oriented by mountain terrain, united by ancestral temples, and sustained by water as lifeblood”.

#### **Construction of fish ridge settlement: Shillong Market.**

According to the record of the Reconstruction of Longxi Yi Xue, Shillong Market, located thirty miles north of Guancheng Market, controlled the circulation of rice grains and other materials in the traditional era of water transportation by relying on its position as the hub of the Dongjiang River system. After the opening of the Guangzhou-Kowloon Railway in 1911, Shillong Market turned into a transit station for land transportation. As one of the four most renowned towns in Guangdong with Guangzhou and Foshan, its market settlements show a typical fish-ridge layout, with the main road as the “spine” running through the core area of commerce and trade, and the parallel extension of secondary laneways on both sides spreading out like “fish ribs”. The main road mainly concentrates on large shops to carry the main traffic function, while the secondary roadway is distributed with small shops to fulfill the secondary traffic function. This spatial structure effectively guides the flow of people through the hierarchical traffic network, forming a unique spatial form of strip type



**Fig. 10** Chashan market settlement street space (Source: Self-drawn).

of market settlements in the era of land and water transport (Fig. 12).

**Landscape spatial pattern.** Shilong Market is situated on the impact plain formed by the confluence of tributaries of the Dongjiang River, surrounded by water systems to the east, north, and south. It faces Boluo of Huizhou and Zengcheng of Guangzhou across the river, forming a settlement landscape pattern surrounded by water on three sides. Located in the heart of Guohe Street, Guanghua Temple was one of the earliest residential areas in Shilong Market due to its high elevation and low vulnerability to flooding. At the end of the Qing Dynasty and the beginning of the Republic of China, as the population increased and the social and economy developed, the area of Shilong Market expanded westward to the Beilian Street area, and the street network began to develop in the northern direction near the water area, mainly to promote the circulation of materials and trade through convenient water transportation. In modern times, the area around Luyuan Street and Shabian Street has become the central area of economic activity in Shilong Market (People's Government of Shilong Town, Dongguan City (2004)).

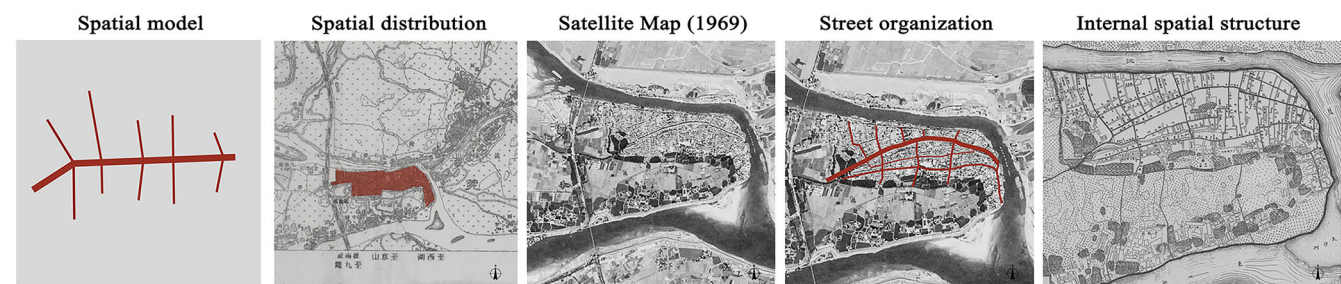
**Street topology.** The centrality of the fish-ridge-type street in Shilong Market demonstrated a dynamic evolution (Fig. 13). Before the mid-Qing Dynasty, Guohe Street, as a main road, reflected in its spatial control, where Ling Wu, Guo Wu, and other clans and Lanruoyuan Temple Buddhist places gathered along the street. Together with Zhongwei Street and Zhuqi Street, they formed the center of commerce in the early market. After the Opium War, seven streets on the south Jiulongyong specialized in the cotton textile industry, and streets such as Tingzhu Street and Zhiluo Street formed an industrial belt of bamboo ware. Meanwhile, Guihua Street and Guifang Street developed a cluster of

grain warehouses of “upper storage and lower trade” relying on the advantages of water navigation. Between 1900 and 1930, the construction of Zhongshan Road reconstructed the central logic of the street, and the combination of Chinese and Western shophouses widened the street by approximately 8 meters, forming a more pressing commercial interface. The buildings along the street are connected by the space of the portico, making the axis from the railway station to the wharf a symbol of the new spatial power. In 1920, businessmen broke through the traditional South Bank economic belt and built new districts such as Gao Street and Haichun Street at Shiwan on the north bank of the North Main Stream, continuing the tradition of “setting up a city because of water” and breaking through the original topological boundary with industrial expansion (People's Government of Shilong Town, Dongguan City (2004)). It should be noted that the centrality of traditional streets is more dependent on the geographical accumulation of clan forces, while the centrality of modern streets is obtained through the location advantage of transportation hubs.

**Architectural form and social space.** During Chen Jitang's reign in Guangdong (1929–1936), the construction of Shilong Market reached its peak. The originally scattered Luyuan Street, Wanxing Street, and other nine streets were integrated into Zhongshan Road, forming a business spindle that was 10–16 meters wide and one kilometer long. Zhongshan Road connects the Shilong Station of the Guangzhou-Kowloon Railway in the west and the Dongjiangbei Main Stream Pier in the east. Along it, there are over 500 two-story arcade buildings that combine Lingnan tradition and Nanyang style (Fig. 14). In these “upper and lower bunk” complex buildings, there are not only traditional business forms such as gold shops and cigarette numbers but also modern industrial facilities such as machinery repair factories, which inject modernity into the traditional market space. In 2012, when



**Fig. 11** Spatial organization model of settlement in Xialang village (Source: Self-drawn).

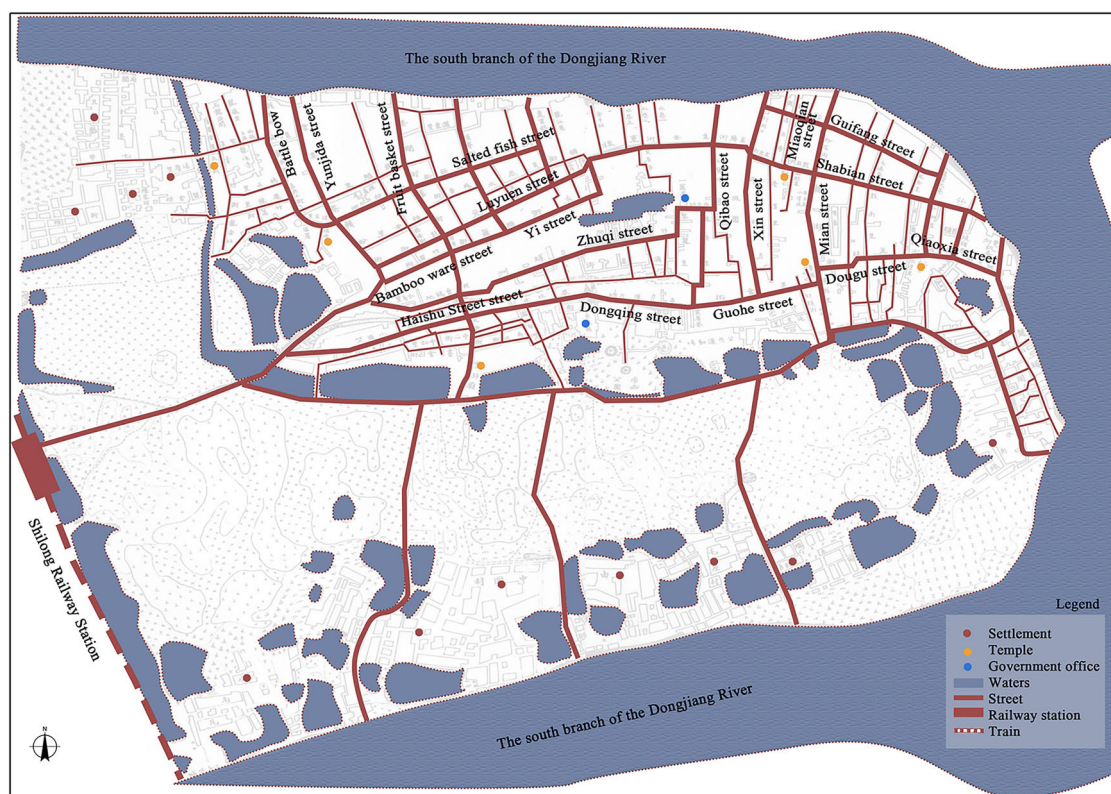


**Fig. 12** Fish-ridge-type Settlement of Shilong Market (Source: Self-drawn).

this section was selected as a historical and cultural street district in Guangdong Province, it still fully preserved eight ancient alleys, 67 historical buildings, ancient trees, ancient wells, and other environmental elements. Moreover, the continuous interface of the shophouses and the transportation axis formed by the railway station and the dock jointly witnessed the spatial practice of the transformation of commercial settlements into modern cities in the era of land and water transportation.

**Construction of grid settlement: Guancheng Market.** The spatial structure of the grid type is a more complex form that evolved after the expansion of the traditional market. As the market scale expanded, a single linear traffic path could no longer meet the

demands of efficient circulation in the market space. Under such circumstances, a more comprehensive road network system began to emerge. It did not follow a fixed template but was flexibly constructed based on the actual needs of the market and changes in the geographical environment, gradually evolving into an irregular grid network. Grid-type market planning often considers specific topographic features, maximizes the functional advantages of different roads through scientific and reasonable street layout, ensures unimpeded flow inside the market, and reserves space for the further expansion of the market. Guancheng Market, the seat of the successive governments of Dongguan with a history of over 1200 years, is a representative settlement of the grid-type market (Fig. 15).



**Fig. 13** Street space of Shilong Market (Source: Self-drawn).

**Landscape spatial pattern.** Guancheng Market is a settlement space formed by the combination of Shiqiao Market, Ximen Market, Dongmen Market, Bei Men Market, and Jiaochang Market. According to the records of Dongguan County Annals · Chongzhen, in the late Ming Dynasty, the market settlement of Guancheng Market was divided into three blocks within the city (Fumin street, Guihua street, Dengying street) and one block outside the city (Yingen street outside the Ximen Market), creating a spatial pattern of four interconnected markets both inside and outside the city, which was the preliminary organization of the spatial structure of Guancheng Market. In the middle of the Qing Dynasty, the demand for trade in Dongguan kept increasing. Based on the Jiaochang market outside the city, it gradually developed into a series of commercial blocks, known as “Twelve Square Streets” in Guancheng Market. In modern times, there were 226 streets in Guancheng Market, with 97 were located in the city and 129 distributed outside the city (Dongguan Guancheng Compilation Committee, 2011) (Fig. 16). This spatial pattern not only maintains the stability of preliminary functional areas such as government offices and academic palaces but also absorbs emerging businesses such as cloth shops and rice markets through the expansion of dock-oriented streets, reflecting the transformation track of market pattern from closed to open in the era of water transportation.

**Street topology.** The centrality of the grid street in Guancheng Market has dual attributes. In the administrative grid unit, with the “ritual system” as the main line, the government office area, cultural and educational area, and religious place form the core of the settlement. The ruling order is manifested through the functional division. The government office area is usually located in the center of the settlement space, reflecting the centrality of power through scale control. The street width near the government office area is wider than that of other

functional areas, and there is a large activity square in front, constituting a power symbol system. In the business district, centrality is achieved through the composite function. The street along the Shiqiao River is superimposed with two-story shop space, and the commercial center areas such as Ximen Market, Beimen Market, and Dongmen Market are equipped with iconic city towers. This centrality creates a unique tension in spatial governance, shaping the coexistence of government districts, cultural and educational districts, commercial districts, and religious sites (Fig. 17).

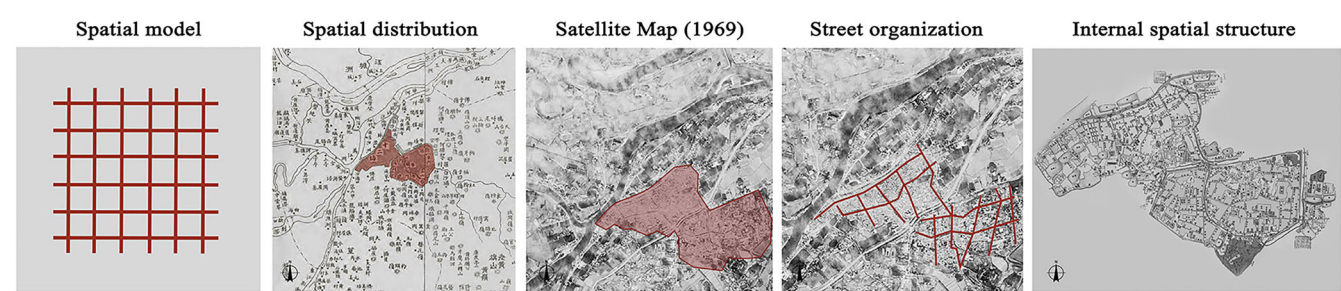
**Motivation of space expansion.** Over the five centuries from the early Ming to the late Qing dynasties, the settlement space of Guancheng Market expanded from 0.8 km<sup>2</sup> to 3.61 km<sup>2</sup>. Its expansion was significantly influenced by population, environment, and economy (Dongguan Guancheng Compilation Committee, 2011). According to Dongguan County Records, the population of Dongguan surged from 76,000 to 1,040,000 between 1391 and 1909. This dramatic increase in the labor force led to the formation of dense warehousing areas and wharves in the river plains. As professional markets spread from the city to the waterfront, a cluster of market towns emerged, creating a checkerboard spatial layout of streets and alleys. In the late Qing Dynasty, the water transport system with Guancheng Market as the center and Shilong Market and Taiping Market as the sub-centers was already established, and the composite form of function was achieved through the three-level penetration of shipping, markets, and settlements.

## Discussion and conclusion

**Discussion.** Based on an interdisciplinary perspective, this study reveals the coupling relationship between settlements and transportation facilities in the traditional market city of Dongguan in



**Fig. 14** The combination of Chinese and Western shophouses (Source: Self-drawn).

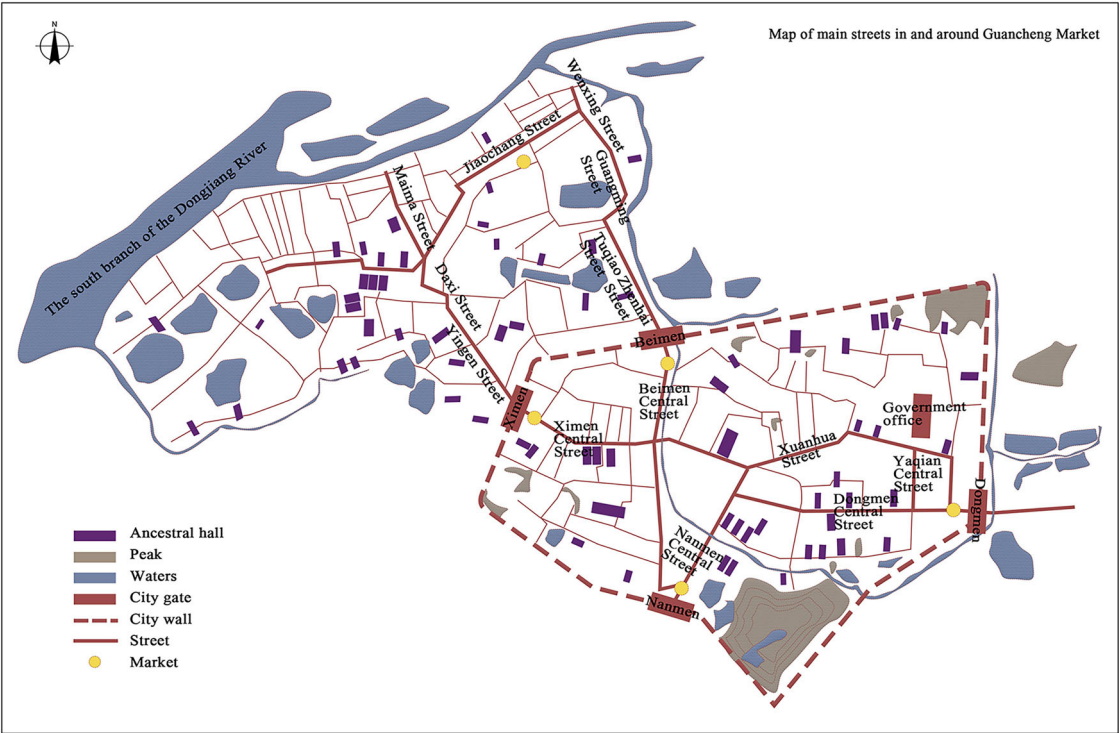


**Fig. 15** Grid type settlement in Guancheng Market (Source: Self-drawn).

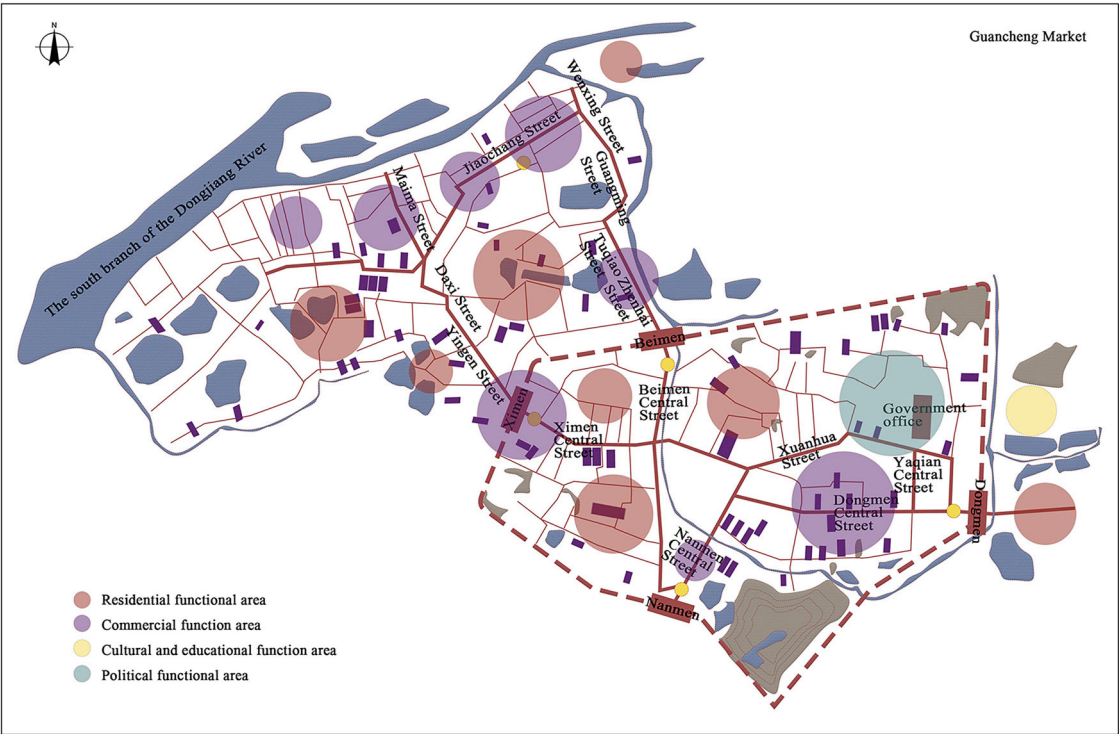
modern times through field investigation, cartography, history, and archive research. It elaborates on the spatial characteristics and construction logic of settlements influenced by land and water transportation facilities.

It is discovered that this differs from the hexagonal homogeneous market model proposed by Skinner (1995) based on the study of rural markets in Sichuan Plain. Market settlements in the Pearl River Delta are restricted by the division

of the water network and hilly terrain forming a heterogeneous spatial system with linear extension and cluster distribution. At the same time, this study discovers that the market settlements in Dongguan have not been fully replaced by the traditional spatial pattern due to the intervention of modern transportation. Instead, they have formed a complex transportation and economic center through “combined land and water transportation”, which differs from the findings of existing studies on the impact of traffic on



**Fig. 16** Street map of Guancheng Market (Source: Self-drawn).



**Fig. 17** Guancheng Market functional zone (Source: Self-drawn).

the development of market cities in northern China (Shao, 2020; Tang, 2021). The Shilong Zhongshan Road Shophouse Market connects railway stations and river terminals in space, creating a composite economic transportation mode. This spatial structure contrasts sharply with that in North China and Jiangnan (Gong, 2000), highlighting the spatial adaptability of Lingnan commercial settlements. In addition, clan forces have a profound impact

on the shaping of the spatial form of the market. The three-level system of “ancestral hall - market - neighborhood” in Guancheng Market and the centrality gradient of the settlement streets in Chashan Market reflect the characteristics of the Lingnan clan in maximizing their interests through spatial production, complementing the depth of the discussion on the Dongguan market in existing studies (Wu, 2014).

At the same time, the establishment of modern transportation facilities has enabled the upgrading of the market level and injected new economic vitality into the market along the line. Changping Market has transformed from an agricultural market to a regional transfer station due to the setting of railway stations, which has also led to the disappearance of the surrounding small market, consistent with the results of previous studies (Xiong, 2017). Regarding the spatial construction logic, Dongguan Market settlements demonstrate the wisdom of adapting to the synergistic optimization of nature and economic development. Through the evolution of the gridded traffic network, Guancheng Market has been expanding towards the coastal waters outside the city, forming a renowned market settlement group. Surrounded by water on three sides, Shilong Market absorbs the advantages of other foreign cultures and builds the architectural interface of the shophouse culture on Zhongshan Road. The spatial pattern of the “mountain peak—dwelling house—pond” in Chashan Market reveals the spatial wisdom of Lingnan farming settlements constructed based on the situation and gathering people by gods. The construction of human settlements in Dongguan Market provides a theoretical reference for understanding regional settlement differences under the influence of clans and promotes global research on the built environment to break through the “Western-centered theory” interpretation framework and establish a more inclusive theoretical system (Eggner, 2002; Wu, 1997). Methodologically, this study employs ArcGIS, CAD, and other technologies to supplement the single limitation of traditional methodology with the help of historical maps, remote sensing image data, and necessary field investigation data (Tang, 2013).

Looking at the market settlements around the world, it can be observed that the development of urban space in many regions is influenced by the transportation facility network, which is worthy of our further discussion. The urban structure of Amsterdam, a canal town in Europe, is deeply influenced by the water system. The lives of almost all residents revolve around the canals, and the settlement space is characterized by a linear distribution. In the late 19th century, driven by trade development and population growth, numerous bridges and roads were built to meet the needs of modern urban transportation (De Klerk, 2020). In contrast, Damnoen Saduak, a Thai market in Southeast Asia, has chosen to adapt to spatial mobility instead of building a large number of fixed transportation facilities (Thongpanya, 2018). This also reflects the spatial organization patterns under the context of social development in different regions. Even though transportation facilities have a catalytic effect on the evolution of settlement space, cultural governance and environmental constraints have led to heterogeneous spatial outcomes. Therefore, these cases necessitate further understanding of the interaction between humans and the environment from a global perspective in the future.

This study still has certain limitations. The selection of research samples restricts the universality of the conclusions. Since the research focuses on the discussion of spatial history, it also determines the lack of empirical assessment regarding the protection of the current status of the settlements in the market. Future studies will establish cross-regional comparative demonstration on this basis, place the case of Dongguan within the global traffic network of the Pearl River Delta, and quantize the spatial differences of different geographical units through spatial regression models (Fotheringham, Charlton, and Brunson, 2000). By integrating social network analysis and space syntax, this paper analyzes the shaping mechanism of street topology by non-material elements such as clan relationships and commercial contracts (Yoon, 1995). At the same time, remote sensing data was employed to monitor the changes in settlement texture in the

market, and a dynamic adaptive protection model was established in combination with community participatory assessment (Selman, 2004). Such expansion can not only improve the theoretical system of traditional settlement research but also provide a scientific decision-making basis for cultural heritage protection in rapidly urbanized areas.

**Conclusion.** This study reveals the spatial characteristics and construction logic of modern Dongguan’s transport facilities and market towns. Influenced by the land and water transport system, three spatial types of market towns emerged: strip, block, and concave-convex. The strip-shaped type extends linearly along the water system, maximizing shipping efficiency with the pattern of “front shop and backport”. The block type builds a closed defense system relying on clan and ancestral buildings, reflecting the need for ritual order, flood control, and war. The concave-convex pattern adapts to the expansion of land power games and transportation networks through irregular boundaries. This non-homogeneous distribution pattern breaks through the homogeneity assumption of Scherzinger’s central place theory and confirms the uniqueness of the market system in the hilly water network of Lingnan. The logic of settlement space construction is reflected in the dynamic coupling relationship between natural conditions and social power. The radiating, fish-ridge, and grid-type street topologies constructed a hierarchical spatial order with temple beliefs, land and water transport, and administrative grids as the core driving forces, respectively. Chashan Market strengthened clan cohesion through the axial distribution of “peaks - houses - ponds”, Shilong Market dominated the development of commerce and trade with the advantages of land and water transport. Guancheng Market achieved synergistic development of politics, economy, and culture through the expansion of the grid of multi-functional zoning. These three cases jointly reveal the wisdom of the Lingnan settlement’s construction, which is ‘adapting to the situation and dynamically adjusting’. It must be mentioned that the intervention of modern transport did not replace traditional water transport, but gave rise to the emergence of composite transport hubs through synergistic effects.

The fieldwork found that Guancheng Market, Shilong Market, and Taiping Market have successively established historical and cultural preservation districts, set up museums for the display of traditional culture, and repaired and maintained important historical buildings. However, due to the rapid expansion of urbanization, the conservation efforts and revitalization strategies for market town settlements seem inadequate. This study has the following implications for current heritage conservation practices: focus on the linked development of transport heritage, incorporate water and land facilities into the revitalization system of the ancient stagecoach route, and set up marketplace cultural interpretation points in conjunction with the stagecoach stations to form a transport heritage tourism loop (Lohmann and Duval, 2011). In addition, drawing on the Kaiping Diaolou “trusteeship system” model (Lin and Lu, 2010), a clan cultural heritage fund can be established to achieve the sustainable operation of the space through the exchange of operating rights. In terms of preservation and detection, the digital twin platform and remote sensing data can be utilized to achieve dynamic monitoring and virtual restoration simulation of heritage conditions, drawing the preservation methods employed in the Lijiang Ancient City (Kong and Hucks, 2023; Zheng, Zhang, Tan and Feng, 2023; Wu et al., 2023; Zhang et al., 2025). These measures will facilitate to go beyond the current paradigm of “static museum-like” conservation and build a collaborative development of “historical context-modern function-community participation” (Selman,

2004; Paniagua, 2023; Sanoff, 1999), thereby achieving a sustainable symbiosis between historical space and modern development.

## Data availability

No datasets were generated or analysed during the current study.

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### Author contributions

JY: Writing—original draft, Methodology, Visualization, Data curation, Fieldwork, Conceptualization. MJ: Writing—review, Validation, Supervision, Fieldwork. JF: Writing—review, Supervision, Fieldwork. All authors reviewed the manuscript.

### Competing interests

The authors declare no competing interests.

### Ethical approval

Not applicable.

### Informed consent

The manuscript is approved by all authors for publication.

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