Spatial Dynamics in the Pearl River Delta and Development Strategies

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DOI
10.1007/978-3-030-89828-1_3

Publication date
2023

Document Version
Final published version

Published in
Adaptive Urban Transformation

Chapter 3
Spatial Dynamics in the Pearl River Delta and Development Strategies

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Abstract The transformation of Pearl River Delta (PRD) is characterized by a complex layering, spatial and temporal differentiation. Its complexity is not only caused by interactions between multiple layers like blue-green spatial structure and urban spatial structure, but also caused by the interactions of several large sub-regions that are mutually interrelated. This paper aims to characterise the spatial structure and its evolution as a basis for the development of spatial strategies for future development. In this research, the combination of multiple spatial–temporal approaches and multiple layer approaches for its spatial structure analysis is employed. Firstly, after mapping the evolution process of the PRD, several important sub-regions are analysed. Secondly, evolution mechanism and driving forces are studied in detail. Thirdly, main existing problems are exposed and the causes of these problems are analysed. Finally, several possible strategies for future land-use schemes of PRD are outlined. It is proposed that the land use of future PRD regions should be divided into three spatial zones and four categories of land use. The goals and measures of development for each land-use category are highlighted in order to make contributions to future planning and design.

Keywords Spatial structure · Pearl River Delta · Evolution mechanism · Correlation; Spatial development strategy

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S. Nijhuis et al. (eds.), *Adaptive Urban Transformation*, The Urban Book Series,
https://doi.org/10.1007/978-3-030-89828-1_3

3.1 Introduction

Spatial structure research has been applied to regional and urban areas by geographers since the nineteenth century. It aims to explore the influence of social, economic, ecological and other attributes on the distribution of spatial structure and is the basis of regional and urban planning (Wang 2018). The analysis of the spatial structure is helpful in discovering the problems of previous planning and design, and to explore the improvement methods of different spatial elements.

The research of spatial structure has experienced the development process from spatial aesthetics, socio-economic ecology and complex spatial networks. The research methods have gradually shifted from static analysis to dynamic analysis, and then to multidimensional spatial-temporal analysis. The study of classical spatial structure takes spatial aesthetics as the core and uses geometric composition rules to guide the process of spatial planning and design (Portugali and Egbert 2016). After the industrial revolution, the spatial structure gradually became relative to the social, economic, ecological and other multidimensional values (Wang et al. 2018). Since the end of the twentieth century, with the progress of global networking, the research of spatial structure to deal with the global social and economic crisis and global climate change has been increasing (Castells 1989). Hot topics such as mobility models and resilience frequently appear in international forums. Looking at the above, although the focus and conclusions of the research on spatial structure is different at different stages, they all rely on the coupling basis of the structured system in the multiple dimensions of element, time and location.

The spatial dynamics of the PRD are the result of the action and interaction of different spatial layers that together form a complex system. The lower basement formed by the erosion and deposition of rivers and oceans and the superstructure formed by the collection and distribution of industries and cities makes it more complex than the general spatial structure system and have more diverse evolution characteristics. For this reason, the issue of the spatial structure of the PRD has triggered a large number of scholars to research, and their understanding of its evolutionary identification and development strategies is also different (Lai et al. 2015; Zhang 2013; Ye 2006; Li and Fu 2014; Li et al. 2005). The formation of the spatial structure of the PRD is not only the result of the mutual feedback of the blue-green spatial structure and the urban spatial structure, but also the result of the interaction of the interconnected, interdependent and mutually coupled large areas. It has the characteristics of time-period dynamics, element stratification and location differentiation. This paper combines the two methods of horizontal division and layer approaches in spatial structure analysis. Through the overlay of different spatial elements, the evolution process and characteristics of the urban spatial structure and the blue-green spatial structure of the whole PRD region, the west upstream sub-region, the west downside sub-region, the east sub-region and the geometric central sub-region are analysed in detail. It studies the evolution mechanism and the driving force behind it, expounds the existing problems of the current spatial structure and puts forward several ideas for the future land-use scheme of the PRD.

3.2 Materials and Methods

3.2.1 Research Scope

The research scope of this paper is the narrow PRD region around the Pearl River estuary, including the main areas of Guangzhou city, Shenzhen city, Zhuhai city, Foshan city, Dongguan city, Zhongshan city, Hong Kong and Macau, as well as parts of Huizhou city and Zhaoqing city. The whole area is surrounded by hilly terrain in the north, east and west side, and the South China Sea on the south side. The hinterland of the whole region is rich of its water systems. There are 102 main rivers and waterways with a total length of about 1700 km. There are eight estuaries including the Ya estuary, the Hutiao estuary, the Jichao estuary, the Modao estuary, the Heng estuary, the Hongqi estuary, the Jiao estuary and the Hu estuary at the boundary of land and sea. The annual rainfall is 1600–2000 mm, the annual average temperature is 21.9 °C and the terrain slope is 0.1‰–0.2‰.

3.2.2 Research Methods and Data Sources

Based on the layer approach, the PRD region can regard its spatial structure as a 'multilayer structure' based on the attributes of its elements. The first layer is the blue-green spatial structure, which is composed of rivers, reservoirs, wetlands, woodlands, gardens, grasslands, oceans, agricultural and fishery land, etc. (Meyer et al. 2015). It is the continuity ecological background which provides the underlying foundation. The second layer is the urban spatial structure, which is composed of the transportation network, residential land, industrial land, commercial land and reserved land for building. It is the lifeblood of social and economic development. Based on a horizontal division, the PRD can regard its spatial structure as a 'multi-area structure' according to its azimuth characteristics (Dai et al. 2017). The first area is composed of Guangzhou city, Foshan city, Zhaoqing city and surrounding areas, which is located in the upper reaches of the west bank. The second area is composed of Zhongshan city, Zhuhai city, Macau, Jiangmen city and surrounding areas, which is located in the middle and lower reaches of the west bank. The third area is composed of Shenzhen city, Dongguan city, Huizhou city, Hong Kong and surrounding areas, which is located on the east bank. The fourth area is composed of Nansha district, the Pearl River Estuary area and surrounding areas, which is located in the central area.

At the same time, spatial samples were collected with the time sampling points of 1980, 1995, 2005 and 2018. In terms of data, the corresponding spatial structure data comes from Landsat remote sensing imagery, Google Earth digital images, Baidu digital images, OpenStreetMap digital images, statistical yearbook (Guangdong Province Bureau of Statistics 2019), official planning and design data (Guangdong Institute of Urban and Rural Planning and Design 1994, 2004, 2008, 2015) and

international journals (Xiong and Nijhuis 2019; Wu et al. 2018; Liu et al. 2015; Gao et al. 2008; Zhao et al. 2017; Li et al. 2018), master and doctoral dissertations, etc. (Chen 2015; Cen 2014). In the study of this paper, the urban spatial structure includes residential land, industrial land, commercial land and reserved land for building. Blue spatial structures include rivers, reservoirs, paddy fields and oceans. Green spatial structures include forest land, garden land, grassland and wetlands.

3.3 Spatial Structure of the PRD Region and Its Evolution

3.3.1 Spatial Structure of the Whole Region

The blue-green spatial structure of the whole region was shaped by the geological faults and magma invasion that occurred during the Yanshan Movement (Lai et al. 2015). Controlled by erosion and siltation, the four basic ecological corridors—West River, North River, East River and Pearl Rivers—have gradually taken shape, providing the main ecological functions for the whole region. The marine spatial structure differs between the east and west banks of the Pearl River Estuary. The west bank is formed by delta tidal dynamics, and its section can be divided into west beach, west channel, middle beach, east channel and east beach from west to east. The east bank is formed by the accumulation of sediment and the sea tide advances and retreats, and its spatial structure is simpler than that of the west bank.

After urban development, the urban spatial structure of the whole region has formed a spatial pattern of 'three zones and four axes' (Li et al. 2018). The 'Three Pieces' refer to the three major urban clusters centred on 'Guangzhou-Foshan-Zhaoqing' metropolitan, 'Shenzhen-Dongguan-Huizhou' metropolitan and 'Zhuhai-Zhongshan-Jiangmen' metropolitan areas. 'Four axes' refer to the east development axis with Guangzhou-Shenzhen Expressway and Guangzhou-Shenzhen Coastal Expressway, and west axis with the Pearl River Delta Ring Express, Xintai Expressway, Guangzhou-Zhuhai Expressway, Guangao Expressway, and north axis of Pearl River Delta Ring, Guangzhou-Foshan-Zhaoqing Expressway, and Guanghui Expressway, and south axis of Western Coastal Expressway, Guangdong-Hong Kong-Macao Bridge, Shenzhen-Huizhou Binhai Expressway and Shenzhong Tunnel. Large-scale public service facilities are mainly concentrated in Guangzhou city and Shenzhen city.

3.3.2 Evolution of the Spatial Structure

Since the reform and opening up in 1978, policies, industries and transportation have greatly changed the evolution process of the spatial structure of the whole region (Gao et al. 2008). In the early period of reform and opening up (1980–1995), the whole

region took advantage of its geographical position and fully absorbed the capital and technology of Hong Kong and Macau. The rapid development of township enterprises, export-oriented processing industries and special economic zones has led to the rise of a number of small and medium-sized cities. In the middle period of reform and opening up (1995–2005), the whole region entered into a stage of rapid urbanisation, with the rapid changing of the industrial structure (Zhao et al. 2017). The phenomenon of export-oriented process of manufacturing industry, increased investment in infrastructure and overall improvement in the indicators of the secondary and tertiary industries have greatly promoted the process of urbanisation. After 2005, driven by factors such as moderate industrialisation, high technology, transportation network and urban spatial integration, the level of urbanisation has shown both quantitative growth and quality improvement. During this period, changes of the spatial structure of the whole region developed from the hinterland to the coast, which promotes the formation of the cross-sea pattern.

The urban spatial structure has undergone an evolution process from 'point axis' to 'network extension' (Liu et al. 2015). The gravity of development of the whole region shifts from the west to the east bank (Fig. 3.1). The 'Guangzhou-Foshan' urban circle and the 'Shenzhen-Dongguan-Huizhou' urban circle constitute the urban development framework. After the reform and opening up, the whole region has shifted from the 'mulberry fishpond'-oriented agricultural production model to manufacturing production model. The whole region takes Guangzhou city, Shenzhen city and Zhuhai city as the regional centre, driving the development of important nodes and forming many growth points.

The blue-green spatial structure has undergone an evolution process of the separation of 'inner circle' and 'outer circle'. The blue-green spatial structure has changed from the 'interdependence' before the reform and opening up to the 'relative restraint' after that period (Fig. 3.2). Before the reform and opening up, the outer blue-green spatial structure provided stable water sources and fertile land, rivers, farmland and green space for the development of the inner blue-green spatial structure and the newly developed city. Four main rivers have also become the basic framework that guides the blue-green spatial structure for an organic whole. After the reform and opening up, with the development of the urban area, the blue-green spatial structure of the inner and outer circles began to separate gradually, and the large blue-green patches connecting the inner and outer circles gradually became less. In recent years, the imbalance of the natural order within the blue-green spatial structure of the inner circle has aroused people's reflection, and they have begun to pay attention to the restoration of local scales.

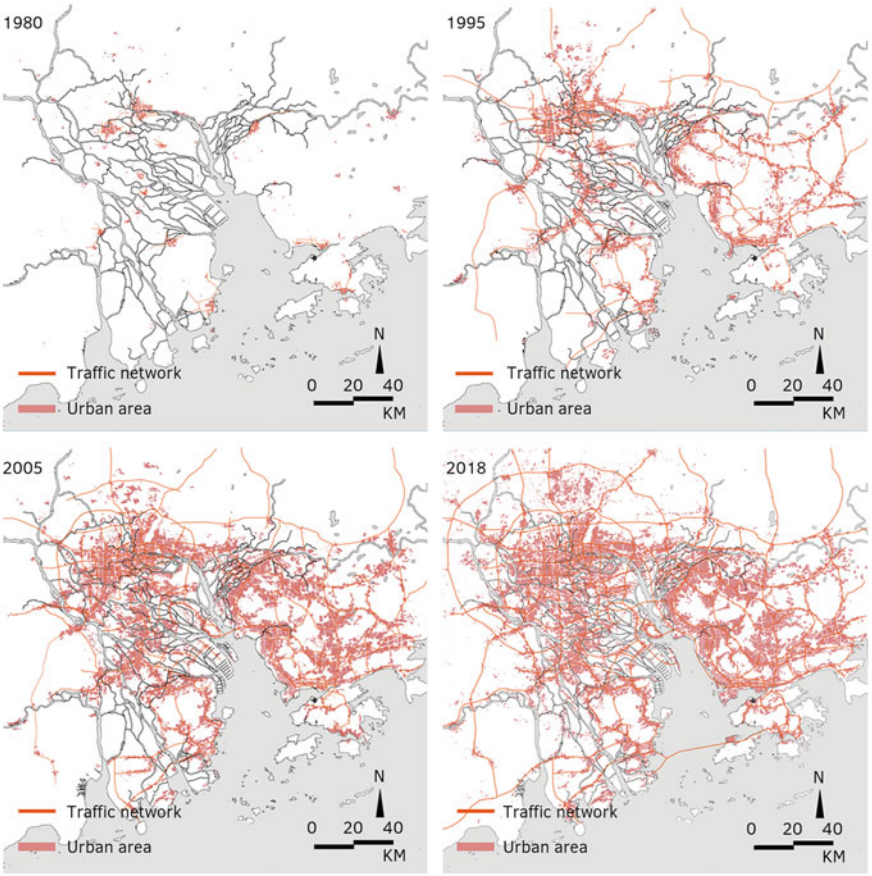

Fig. 3.1 Development of the urban structure in the PRD. *Image* Dai Wei

3.3.3 The Evolution of the Spatial Structure of the Sub-regions

Due to the differences in the history, resources, environment and other factors of the spatial structure, the starting point, path and results of development of each sub-region are different. Therefore, the spatial evolutions of different sub-regions in the whole region are also quite different.

3.3.3.1 West Upstream Sub-region

The west upstream sub-region has the best terrain and good infrastructure (Fig. 3.3). The formation of the delta in this sub-region is the earliest, with high terrain, flat

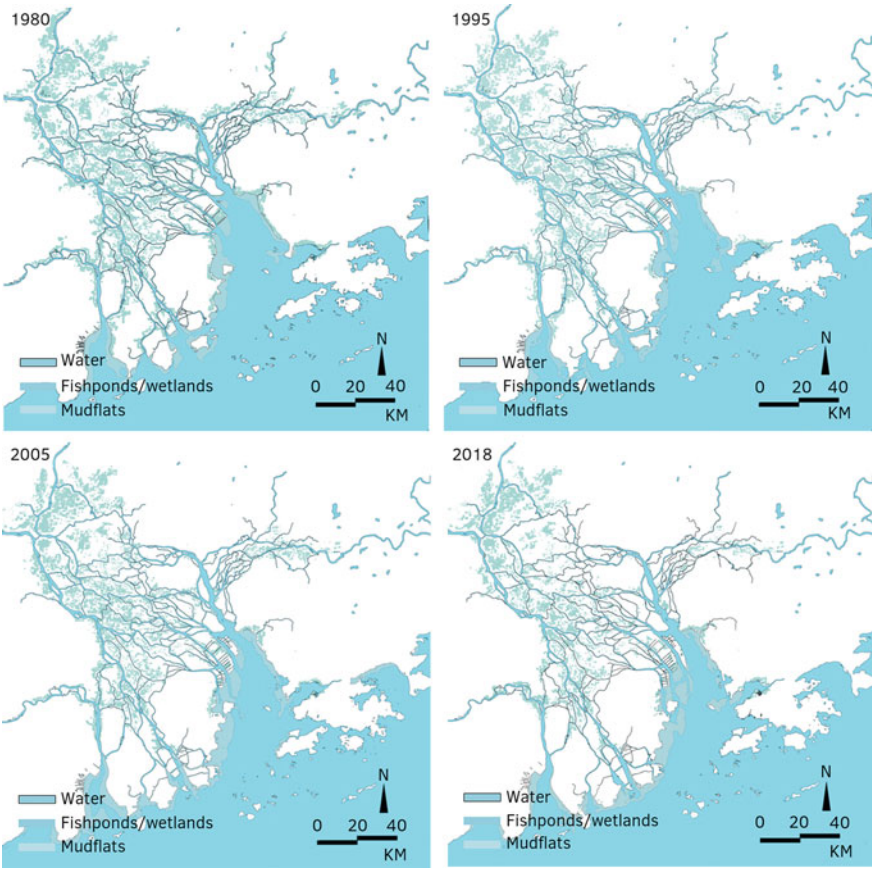

Fig. 3.2 Development of the blue-green spatial structure. *Image* Dai Wei

terrain, large soil porosity and good water permeability. These characteristics are conducive to the development of the city by the form of concentric circles. At the same time, Guangzhou city, Foshan city and Zhaoqing city are all historical cities. Many satellite towns have been formed in the long-term development history. They have a solid historical background and have the ability to develop rapidly in terms of population conditions, industries and infrastructure. The main features of the urban spatial structure in this sub-region are the 'circle spread' and the 'cross radiation network'.

From the perspective of the blue-green network structure, the natural environment in the sub-region has less restriction on urban development (Fig. 3.4). In Nanhai, Shunde, Panyu and other districts, orchards, green spaces, ecological bases, etc., have all been reduced in large areas. Affected by the expansion of the construction scope, they have shown a trend of irregular transformation. Due to the impact of regional projects such as riverbed sand mining and dam construction, the diversion

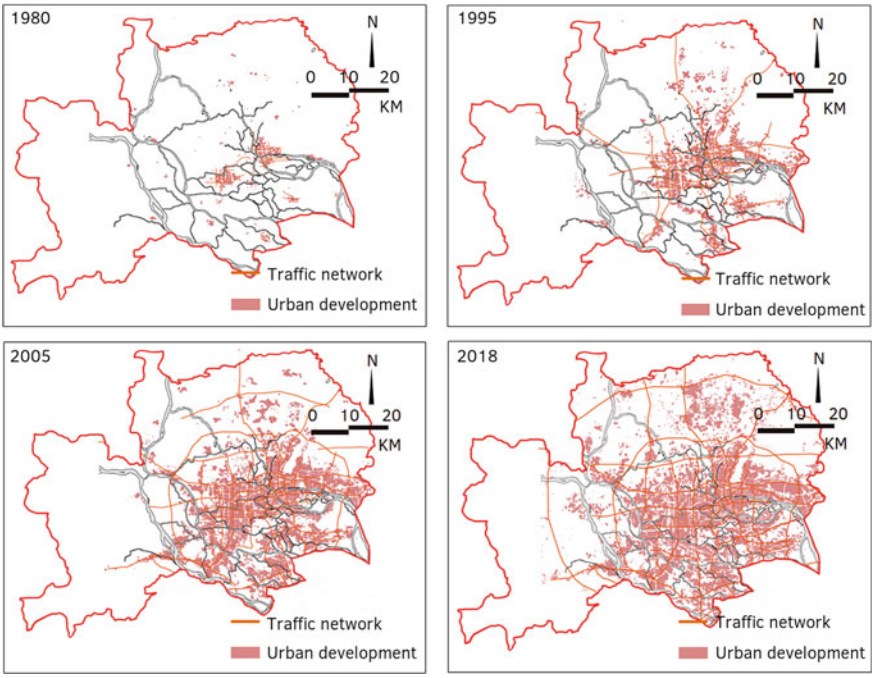

Fig. 3.3 Evolution of urban spatial structure in the west upstream sub-region. *Image* Dai Wei

and sand distribution ratios in the upper reaches of the North River and the West River have changed, further increasing the risk of regional soil erosion. From Baiyun Mountain, Maofeng Mountain, Danan Mountain and other western mountains to the Pearl River and North River, the original large-scale ecological hydrological corridors are all fragmented.

3.3.3.2 West Downstream Sub-region

The rate of urban expansion in the west downstream sub-region has always been lower than that of the other sub-regions (Fig. 3.5). As Zhuhai city's leading industries have undergone many changes in commerce, tourism, real estate and industry, though their development momentum has not been strong in some periods. In Zhongshan city, Foshan city, Dongguan city and other cities, although township and village enterprises have developed rapidly, the urban spatial structure mainly revolves around the construction of industrial plants. Zhongshan city and Zhuhai city are guided by the bottom-up development model of township industries, and a large number of clustered and dispersed forms based on specialised towns have been formed. Because this kind of form is not guided by the main axis, the development pattern is often random. The urban spatial structure of this area is generally 'multi-point scattered'.

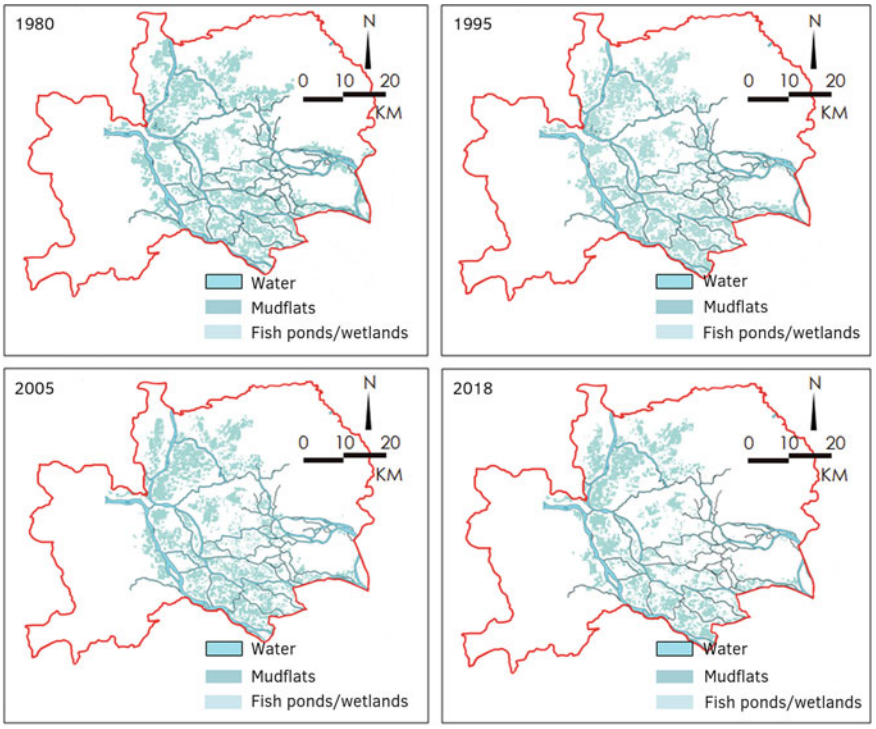

Fig. 3.4 Evolution of the blue-green spatial structure in the west upstream sub-region. *Image* Dai Wei

Different from other sub-regions, this sub-region has many water corridors, densely tributaries and remarkable tidal currents (Fig. 3.6). Therefore, the evolution process of the blue-green spatial structure is more complicated. The urban-rural stretch area is an area where the blue-green network structure is severely broken, and the blue-green patches at the centre and the edge locations are severely broken off. The south-western coastline is reclaimed from the sea and the coastal pattern is relatively fragmented, which affects the dynamics of runoff and tidal currents and marine habitats.

3.3.3.3 East Sub-region

In the early stage of reform and opening up, the infrastructure of the east sub-region was weak (Fig. 3.7). Therefore, planning and regulation play an important role in the spatial development of this sub-region. The border area between Shenzhen city and Hong Kong quickly became the centre of regional development. Dongguan city has taken advantage of the radiant influence of the 'Shenzhen-Hong Kong' development centre. The rise of a large number of industries and manufacturing

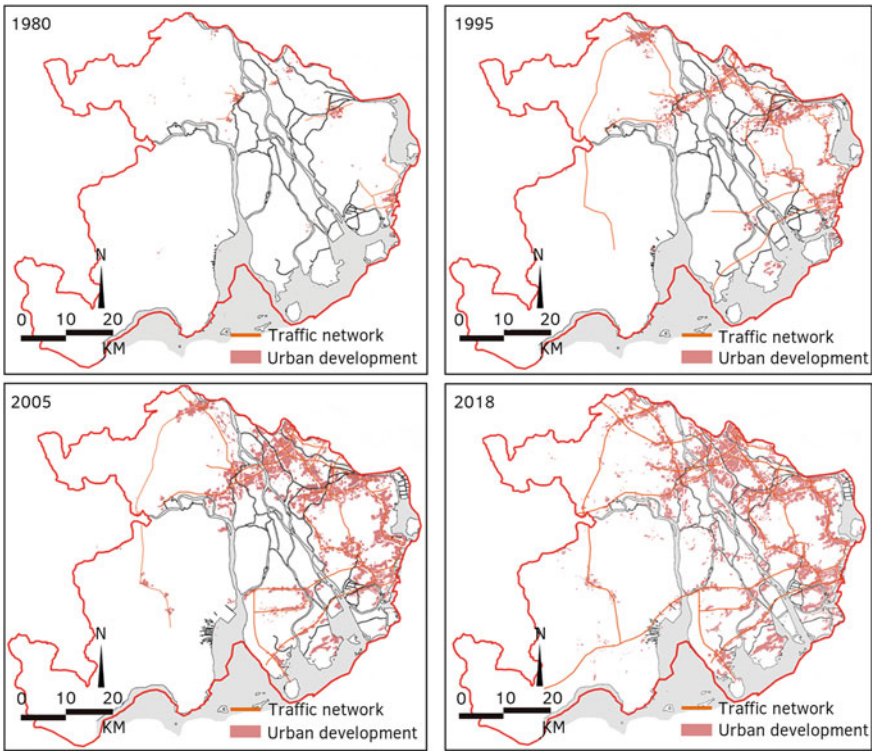

Fig. 3.5 Evolution of urban spatial structure in the west downstream sub-region. *Image* Dai Wei

industries has caused the centre of entire region's social and economic circle to continuously shift from west to the east coast. The urban spatial structure of this sub-region is generally based on the development model of 'belt radiation' and 'spreading and filling', forming a linear finger-shaped spatial development pattern.

From the perspective of the blue-green spatial structure, the natural topographical conditions of the mountainous terrain in the sub-region have a great restrictive effect on the urban spatial development (Fig. 3.8). Compared with other sub-regions, there is a significant increase in green patches from large to small, which mainly occur in important ecological corridors such as mountain edges. At the same time, due to the excavation, dredging and reclamation, the mangroves were destroyed and the shallows expanded.

3.3.3.4 Centre Sub-region

Taking advantage of the port, the geometric central sub-region determined the development orientation of key industries with the port as the core element and the marine industry as the backbone at the early stage of development (Fig. 3.9). After 2010,

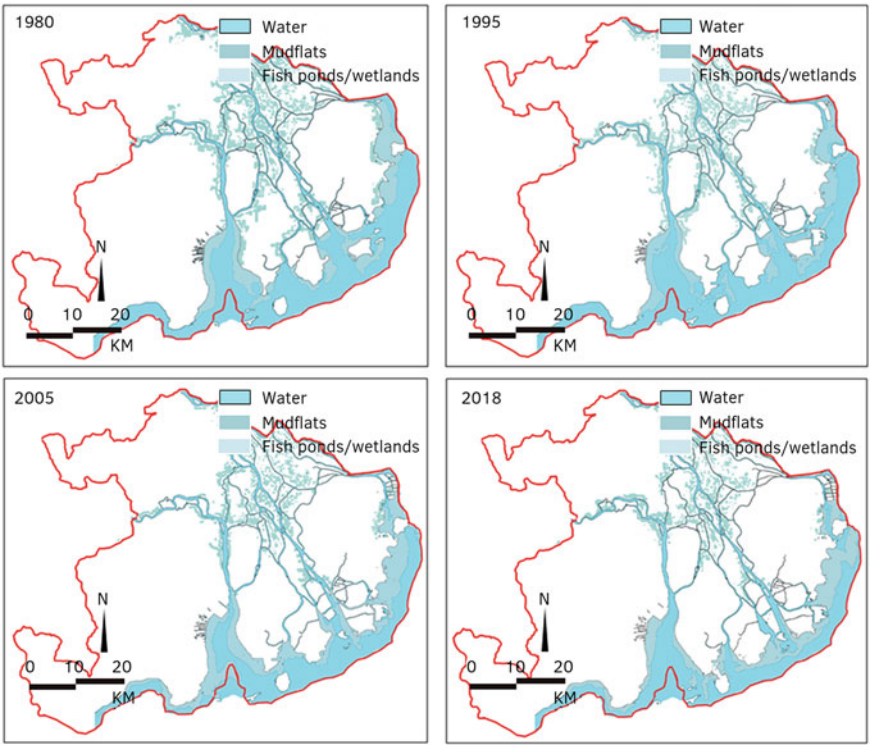

Fig. 3.6 Evolution of the blue-green spatial structure in the west downstream sub-region. *Image* Dai Wei

combined with Nansha Port and Guangzhou Metro Line 4, a sea-land-rail transportation network was formed. Since then, Nansha district has built a series of important transportation infrastructure on a large scale. The 'staggered' space formed by Nansha Port Expressway, Humen Bridge and other roads has become the spatial framework of Nansha district's development.

Since most of the land in the sub-region has not yet been developed, the blue and green spatial texture of the 'mesh-pattern' is still reserved (Fig. 3.10). The scattered pattern of the original green space, the culture of the people living along the water and the complex and intertwined delta trail trends constitute the characteristics of the geometric centre sub-region. Due to the progress of reclamation projects on Wanqingsha Island and Longxue Island, the original blue-green spatial structure has gradually been occupied.

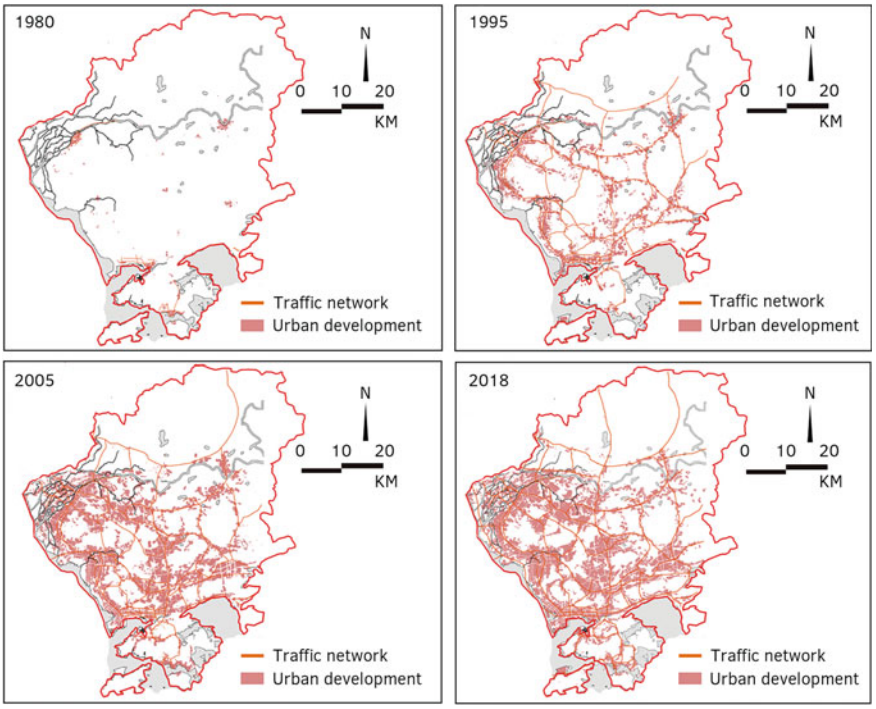

Fig. 3.7 Evolution of the urban spatial structure in the east sub-region. *Image* Dai Wei

3.4 Drivers of Spatial Change

Based on the research of the evolution of spatial structure, the following three points are identified as the main drivers of spatial changes.

First, the polarisation and diffusion effects are the driving force for the development of space from homogenisation to heterogeneity. The combination of social and economic forces, natural conditions, industrial agglomeration and proliferation, transportation networks, infrastructure and local factors has accelerated the generation of spatial heterogeneity, which has continued to evolve from single to multiple and simple to complex. The research shows that the spontaneous dynamics of the evolution of the blue-green spatial structure of the whole region conforms to the circle layer effect of landscape evolution. Under the mutual feedback of natural order and artificial order, through the process of polarisation and diffusion, the inner and outer circles are separated from each other and the situation of ecological hydrological resources are unevenly distributed. The spontaneous driving force of the evolution of the urban spatial structure in the whole region is in line with the block effect of urban evolution. Under the mutual feedback of natural order and artificial order and through the process of polarisation and diffusion, a situation where the centre-periphery constraints are mutually restrained and the social and economic public

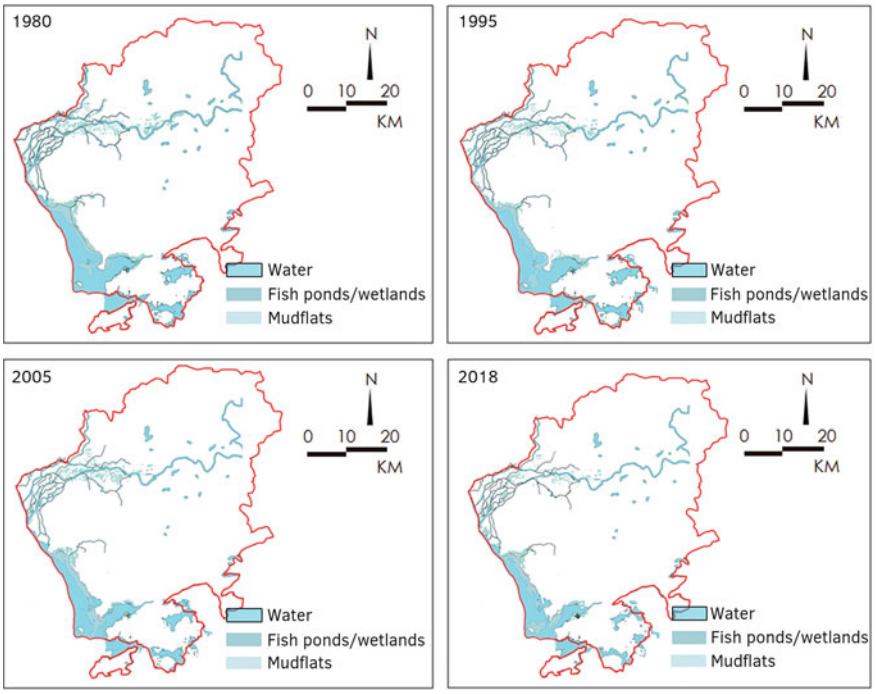

Fig. 3.8 Evolution of the blue-green network structure in the east sub-region. *Image* Dai Wei

resources are unevenly distributed occurs. The overall spatial structure embodies the evolution of complex systems from a single-core model to a dual-core model, and then to a multi-core network model.

Second, geographical conditions, transportation infrastructure, industrial agglomeration and ecological hydrological resources are the engines that affect the evolution process of the spatial structure. In different historical stages and different geographical spatial locations, these geographical conditions have great differences in the displacement of spatial elements in the whole region. When the whole region enters a stage of rapid development, the role of physical geography in the evolution of spatial structure will be reduced with the construction of infrastructure such as transportation, dams and power networks. Among them, the improvement of the transportation network promotes the development of the spatial structure of the whole region from point axis to network, and breaks the original homogeneous spatial pattern, replacing it with a new form. Under the combined influence of geographical conditions and infrastructure, a belt-like extension of the spatial structure of Zhuhai city and Shenzhen city in coastal areas, a scattered extension of the spatial structure of Zhongshan city, Dongguan city and Jiangmen city in mountainous areas, and a concentric extension of the spatial structure of Guangzhou city and Foshan city in plain areas have been created. The distribution of industrial structure and ecological resources will also drive the reorganisation of the spatial structure.

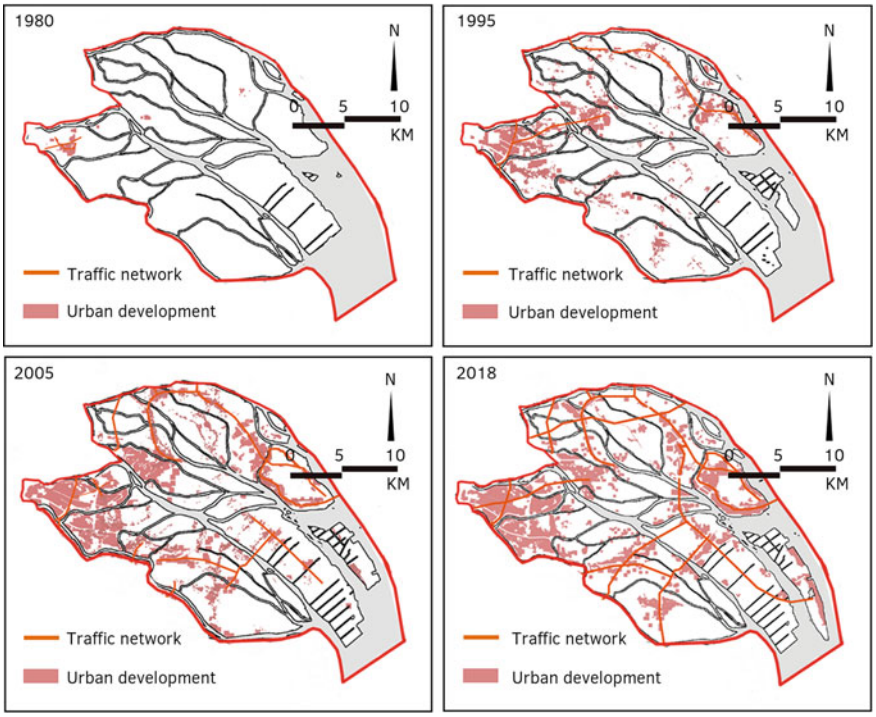

Fig. 3.9 Evolution of the urban spatial structure in the geometric centre sub-region. *Image* Dai Wei

Third, top-down and bottom-up development models exist. In the top-down development model, the changes in the spatial structure are mainly manifested in the infill pattern formed by the centralised large-scale infrastructure and projects. Therefore, both the evolution of urban spatial structure and the blue-green spatial structure are relatively concentrated and compact. In the bottom-up development model, the location of spatial evolution is relatively loose, which objectively affects the difficulty of social-economic development and comprehensive management of the environment. Throughout the whole region, Guangzhou city, Shenzhen city and Zhuhai city belong to the core radial type. They have a concentrated and compact spatial development pattern and have strong spatial vitality. Foshan city, Dongguan city, Zhongshan city and Nansha district are part of the continuous belt-axis, which has a continuous and relatively loose cluster form.

3.5 Problems of Existing Spatial Structure

Based on the research results, the current spatial structure of the whole region has the following problems. First, the development of urban spatial structure is insufficient,

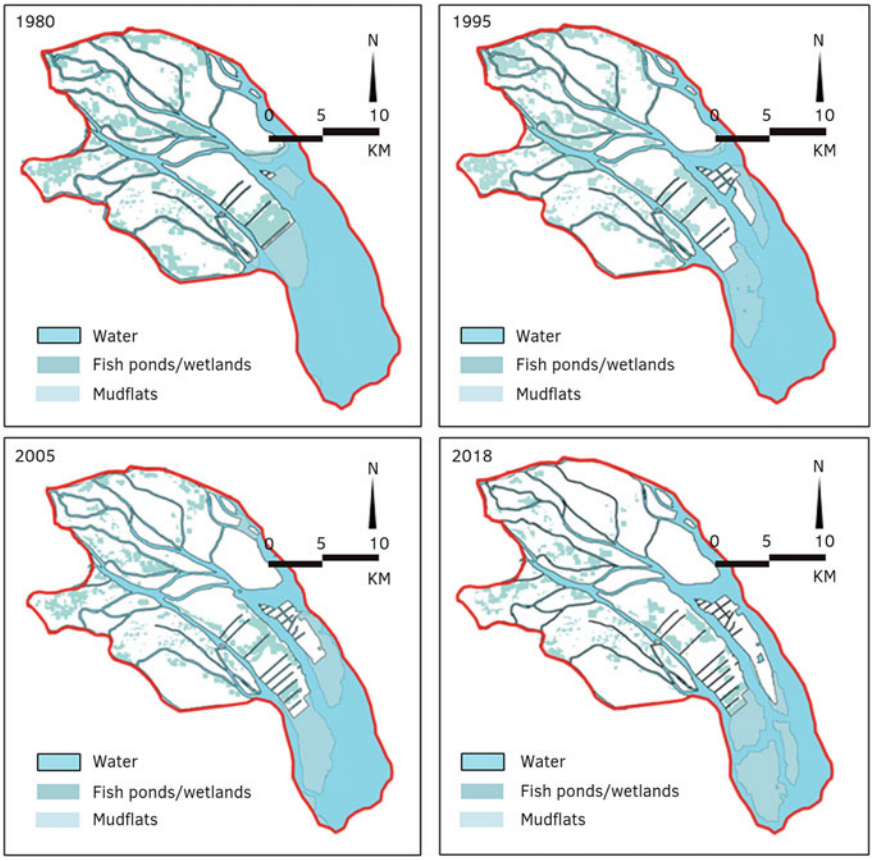

Fig. 3.10 Evolution of the blue-green spatial structure of the geometric centre sub-region. *Image* Dai Wei

and there is a lack of coordination between sectors. The main manifestations are: (1) uneven distribution of traffic network. The west upstream sub-region has the highest internal traffic connection degree, and a highly integrated 'cross' axis topological network has been formed. The east sub-region is the second connected sub-region, with a highly integrated 'linear' axis topological network. The geometric centre sub-region is highly integrated, but the peripheral area often has only one main arterial road without forming a networked traffic structure. (2) There is a situation where the development of various sub-regions is not coordinated. Looking at the overall situation, most of the population and public service facilities are only distributed in Guangzhou city, Foshan city, Shenzhen city and other cities, which results in excessive pressure on the current land resources. (3) The production, life and hydro-ecological functions of the marginal areas are mixed. Due to differences in land development mechanisms and management, many specialized towns have appeared

in many fringe areas, but the spatial polarization effect is not strong, the land use is relatively extensive and the industrial layout is relatively scattered.

Second, the evolution of the blue-green spatial structure tends to deteriorate, affecting the stability of the hydro-ecological background of the whole region. The main manifestations are as follows: (1) the depth, width and length of the riverbed change. Excessive sand mining in the upstream riverbed has caused irregular changes in the depth of different sections of the river channel, changing the diversion and sand distribution ratio of important forks. The construction of large-scale dams, river-crossing bridges and wading projects reduces the effective width of the river channel and reduces the capacity of the river channel to regulate and store water. The effect of water recuperation in large-scale dam projects may cause the natural erosion and siltation characteristics of some rivers to be reversed. The wading project causes the sediment to be deposited in advance, reduces the amount of sedimentation at the entrance and increases the possibility that the water and soil structure of the entrance will be eroded by tidal dynamics. (2) The high-value wetland system in the inner circle has been changed, and the connected ecological confluence path is missing. A large number of mulberry fishponds along the line of Foshan city, Zhongshan city and Shunde city have been used as urban construction land, and high-value wetlands have been cut and split, which results in the decline of hydro-ecological functions. The structure of mangrove vegetation in the middle and lower reaches was destroyed, and the biodiversity and tide resistance of the shoreline declined. The agricultural expansion of the hills, the development and utilisation of the mountains and the compaction of the soil due to construction have changed the original flood control vegetation and soil structure of the mountains, increasing the probability of soil erosion by heavy rain, and easily causing the outbreak of mountain torrents and mudslides. (3) The nature of the estuary changed dramatically and siltation is serious. The Lingdingyang west beach was squeezed to the south-east by sedimentation, causing the axis of the west channel to move to eastward. The mudflats on both sides of Modaomen Port and Hengqin Port have been reclaimed as land, and the wide sea area has been narrowed into artificial navigation channels. The Jiti estuary to the sea was separated from the Huangmao Sea, causing serious siltation on the east side.

3.6 Strategies for Spatial Development

3.6.1 Construct a Unified, Integrated and Related Compound Regional Corridor

At present, the bottleneck for the future development of the entire Pearl River Delta remains due to the problem of insufficient and uncoordinated spatial connection. The coordination and establishment of complex, three-dimensional, networked transportation and hydro-ecological corridors should be the focus, and the existing infrastructure should be optimised and used as an important support for spatial adjustment

to enhance the radiation effect from the coastline to the hinterland. A connective corridor is the foundation of global linking, and it is also the coordinated guide in the evolution of the structure and function of the region. The future development should be based on important corridors, relying on the axis of construction in different periods, such as the Western Guangzhu Expressway, the Southwest Coastal Expressway, the Northern Guanghui Expressway, the Southern Guangdong-Hong Kong-Macao Bridge and the Eastern Guangshen Coastal Expressway. By encrypting traffic network construction and public service systems in weak areas, central-peripheral point aggregation and diffusion effect can be optimised. This is necessary to help the ecological and hydrological regulation of spatial elements, such as mountains, water, sea, forests, gardens and fields, to optimise the basement pattern, to maintain existing ecological hydrological corridors, protect important rivers, foundation ponds and other high-value ecological elements and to reshape the ocean surroundings. The riverbed restoration and tidal flat reconstruction of the four main water corridors of the North River, West River, East River and Pearl Rivers should be coordinated to keep the diversion and sand distribution ratios of key bifurcations within a reasonable range.

3.6.2 Coordinating Three Spatial Zones

New land-use schemes need to consider both natural and urban spatial resources. The development of the PRD is influenced by the difference of natural resources and has formed results in three-circle spatial differentiation characteristics. Therefore, a new land-use scheme is suggested with the consideration of three-circle spatial differences. The first circle is the coastal circle. It is necessary to make full use of the advantages of sustainable ports to construct the coastal protection belt. The biodiversity, coastal protection and brackish water interaction should be well considered. The second circle is metropolitan development circle, which is located between the coastal circle and the natural protection circle in the mountainous area. This circle provides the most mutual feeding between the urban development space and the blue-green space. Land-use regulation should focus on the construction and restoration of urban internal ecological corridors and opening green space. It is necessary to conform to the blue-green spatial texture and control the urban disorderly sprawl rate. The third circle is the natural protection circle of large and high-valued reservoirs and mountainous regions, which are important for water storage and soil conservation.

The socio-economic and cultural resources in the PRD have resulted in the differentiation characteristics between urban and rural space. The ‘Guangzhou-Foshan-Zhaoqing’ metropolitan area and the ‘Shenzhen-Dongguan-Huizhou-Hong Kong’ metropolitan area have many large urban resources, well-developed infrastructures and well-developed urban functions, but they lack land resources. These areas should consider the strategy of urban-rural renovation and avoid continuous actions of urban sprawl. Attention should be paid to the construction of hydro-ecological corridors inside the city, and the implementation of the restoration of small river corridors

and the construction of green open space in the city. There are many current ecological hydrological corridors in the 'Zhuhai-Zhongshan-Jiangmen' metropolitan area, especially the West River and the North River which have many capillary corridors that can provide important regulation effects. Therefore, while increasing the service density of public facilities, it is necessary to focus on building blue-green structures with self-organisation capabilities.

3.6.3 Zoning Categories for Regional Land Use

The land-use scheme suggests dividing the land use of the whole PRD region into four categories, with different land-use strategies based on the understanding of terrain condition, land characteristics, collaborative effects between sub-deltas and long-term protection and development process. These four categories are natural protection areas, agricultural development areas, urban development areas and coastline areas (Fig. 3.11).

3.6.3.1 Natural Protection Areas

The land-use scheme suggests that natural protection areas should be concentrated along the West River and the North River, coastline, estuaries, as well as the outer circle mountains. Several measurements need to be taken for long term, natural, bottom-line operation. It is necessary to take natural geographic boundaries as research units, take large blue-green patches as the core elements and formulate corresponding construction regulation according to environmental capacity, resource carrying capacity. It is important not only to restore the natural shape of the river and green space, but also to solve the problem of disordered texture caused by urban squeezing. Natural protection areas should play their roles in ecological conservation, biological maintenance and hydrological regulation. It is wise to pay attention to nature-based solutions and advocate the conversion from dyke engineering to work with nature. It is necessary to strengthen the protection of coastal landscapes, take into account the diversion ratio of natural coastlines and artificial coastlines by controlling the length of the building that can occupy the coastline. It is important to strengthen protection measures for the eco-environmental area near the coastline and to make compensations for excessive reclamations in order to increase the capacity of the tidal storage by estuaries. As an inside natural protection area, the Pearl River Estuary is the first barrier to be protected. The land-use scheme suggests focusing on the sea-land transition environment, protecting the existing wetlands, building a coastline protection belt and promoting the biodiversity of the bay area.

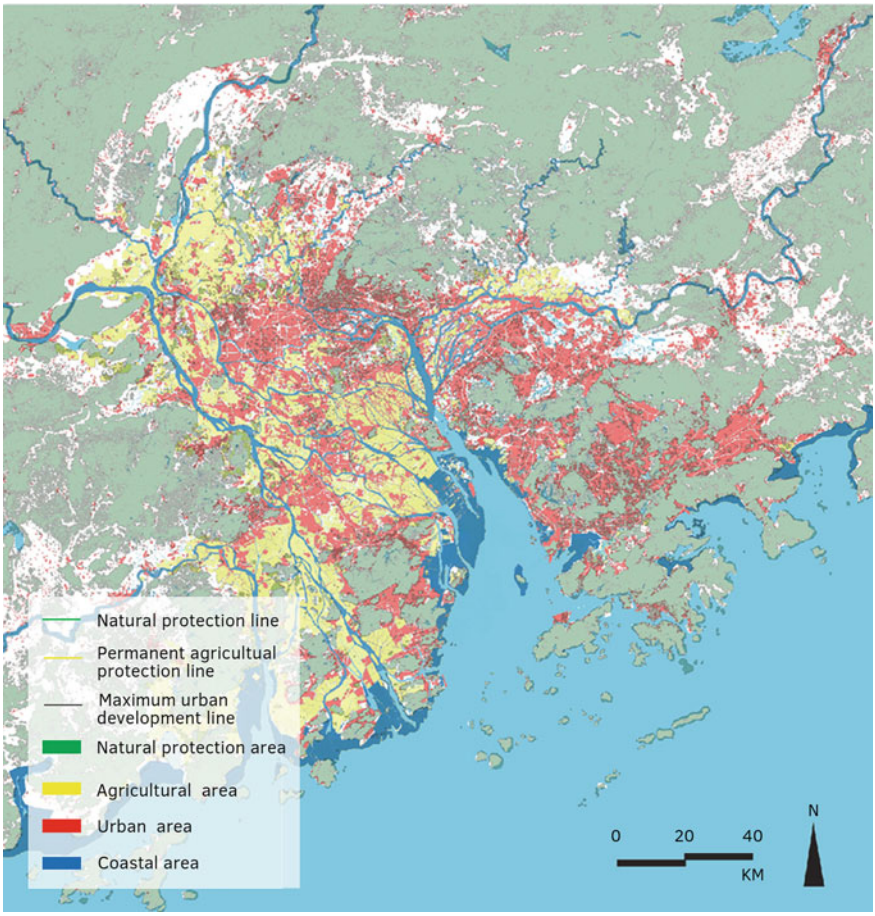

Fig. 3.11 Potential spatial development strategies for the PRD. *Image* Dai Wei

3.6.3.2 Agricultural Development Areas

The land-use scheme suggests that agricultural development area should be distributed in between natural protection areas and urban development areas, which cannot only function as a buffering area for further utilisation, but also provide the traditional cultural landscape of mulberry fishponds. From the evaluation results of agricultural land-use suitability, Foshan city, Dongguan city, Zhongshan city and Nansha are suitable for agricultural development. According to land-use suitability assessment, different kinds of crops should be cultivated in order to ensure food provision service for the PRD.

Specifically, the suitable agricultural areas in the west side upstream region are dominated by the current inter-city wasteland. The soil and water condition are suitable for Foshan city, Shunde and other places to strengthen the development of

fishpond agriculture and advocate for a 'fish-mulberry' circular agricultural economy near the fringe agricultural land of Guangzhou and Foshan towns. It is important to improve farmland infrastructure conditions and raise farmland standards. The suitable agricultural land in the west side downstream region dominates in large areas of undeveloped fishponds, which can be used as the core lands for cultivating and fishing. It is important to strengthen the protection of fishponds along the Doumen, Xinhui, Qijiang and Zhongshan city areas, and form a modern standard agricultural concentration area with concentrated splicing, completed infrastructure and valuable travelling place. The suitable agriculture land in the east region is mainly located along the East River. It is necessary to ensure that the farmlands in the basic protection areas should not be decreased for promoting the cultivation of wastelands. The suitable agriculture lands in the central region are located in Nansha and Wangqingsha. Some low-lying areas should be reserved as useful supplements to agricultural land and urban landscape in future.

3.6.3.3 Urban Development Areas

The land-use scheme suggests that urban development areas can be concentrated in high-valued lands along the existing large cities like Guangzhou city, Shenzhen city and Zhuhai city. It is important to properly increase the density of traffic network and provide as many types of public facilities as possible, and rely on the advantages of public services, infrastructure and facilities to increase the proportion of commercial finance, trade fairs and corresponding businesses. It is necessary to coordinate urban development areas with the natural protection areas, to scientifically insert parks and lakes to the existing urban lands in order to create attractive landscape for future residence. Based on factors such as topographical conditions and environmental capacity, it is necessary to change the development model from 'extensive' to 'intensive'. For port areas, the south side of offshore areas should focus on coordinating the construction of ports and reclamation of islands. The outline of ports, as well as their related logistics layout, should be coordinated with the dynamics of sedimentation and erosion of the sea.

The suitable urban lands in the westside upstream region rely on the existing cities of Guangzhou, Foshan city and Zhaoqing city and combine with the existing road network. The suitable urban lands in the westside downstream region are centred on Wugui Mountain, along the Zhongshan–Xiaolan–Shunde axis and along the Zhuhai coastline on the eastern side of Wugui Mountain. The suitable urban lands in the east region are dominated by the corridors along the main rivers in Dongguan city and Shenzhen city, as well as on both sides of Yangtai Mountain and Yinping Mountain. In future, new construction lands should be strictly controlled due to limited land resources. The suitable urban land in the central region is mainly concentrated in the north of Nansha. Relying on the port and navigation of the Pearl River Estuary, it is important to coordinate the development of port, industry and city. The urban structure in the future should transform from scattered to networked, which can create

a modern service industry basement and an advanced manufacturing basement with inland backing.

3.6.3.4 Coastline Areas

The land-use scheme suggests that coastline area should be mainly distributed at the estuaries and coastline areas in cities, which are important spaces for fluvial-tidal interactions in the PRD. Because of its specific condition, several measurements need to be taken for long-term operation. It is important to address the relationship between construction, industrial development and natural protection and pay attention to the repair and maintenance of offshore mangroves. It is furthermore important to protect marine islands and improve marine resources, reasonably control the proportion of various types of shorelines and scientifically allocate the use of productive, living and ecological water. According to the differences of water depth, deeper water can be used for production-oriented shoreline function, while the shallower water can be used for life and hydro-ecological shoreline functions.

3.7 Conclusion

The PRD has a particularly important strategic position and plays a decisive role in China's social and economic development. In the process of long-term spatial competition and cooperation in the past 40 years, the PRD has formed a distinct pattern caused by clusters and differentiated model. The formation of the spatial structure of the PRD is the result of the mutual feedback of the blue-green network and the urban space. It has the characteristics of time-period dynamics, element stratification and location differentiation. The interaction between social, economic and ecological development and factors, energies and information in the long-term evolution has created the development background, opportunities and challenges of the entire region. This paper gathers research results and proposes that the future spatial evolution of the PRD should first strengthen its strategic position from national scale, improving overall synergy and achieving win-win cooperation across the globe. Secondly, based on the evolution background and current conditions, composite three-dimensional regional corridors are constructed to create a circle and block global structure. Finally, it focuses on the model of three-circle spatial coordination and four categories of regional land use, namely natural protection areas, agricultural development areas, urban development areas and coastline areas. The strategy utilises key projects through composite corridors to make the entire Pearl River region prosperous.

Acknowledgements This research was partly funded by the NSFC, NWO and EPSRC Joint Research Project Adaptive Urban Transformation (AUT)—Territorial Governance, Spatial Strategy

and urban Landscape Dynamics in the Pearl River Delta (grant no. ALWSD 2016.013, sustainable delta programme), and also funded by the Science Foundation of Zhejiang Province, China (LQ22E080016), China Scholarship Council (No. 201606150035).

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