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Developing underground spaces in Chinese new towns: The case of Nanqiao

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Abstract

Since the reform and opening up of China (1978), urbanization has progressed rapidly under the government's leadership. As a result, many new towns have sprung up on the edge of cities, changing the urban and rural landscape of China. The new towns in China have significantly contributed to promoting economic development, optimizing the spatial structure of cities, and attracting people to live and work. However, the construction of new towns has also accumulated many problems over the past forty years, such as waste of land resources, over-construction, lack of attractiveness, and homogenization, inspired by the idea that developing underground space can alleviate existing urban development ills, this thesis aimed at exploring strategies to solve urban problems of new towns by developing underground space. Nanqiao new town, as a typical case of transformation and upgrading from an economic development zone to a comprehensive new town, was selected as a case study for this dissertation because of its advantages and problems in the development process. After understanding the urbanization background and development status of new towns in China through literature review and case analysis, this thesis used secondary data analysis, fieldwork and case analysis to explore the development strategies of underground space in new towns. The secondary data analysis and field survey helped forecast the scale of underground space development in Nanqiao new town and assess its natural environmental suitability and socio-economic conditions for underground space development. A large number of case analyses contributed to summarizing the strategy of underground space development in the new town. The results found that underground space development in the core area of the new town can help stimulate the growth momentum of the new town and promote intensive development; the multifunctional underground space, which is typical of the combination of leveling and warfare, can increase the attractiveness of the new town and provide a safe, resilient and sustainable development environment for the new town; underground space development can also directly reduce

the environmental damage caused by the construction of the new town, and the underground space connection project can promote the complementary functions of the new town and efficient and provide a foundation for the future development of the new town.

Key words

Chinese urbanization, Chinese new town, underground space, urban problems, Development strategies

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Index

Figures Index

Tables Index

Introduction

One of the most apparent manifestations of the urbanization process led by the Chinese government after the reform and opening up (1978) is the birth of many new cities. For a long time, the mechanism of the creation of new towns in China, their contribution to economic development, and the pros and cons of urban development have been hotly debated by scholars. Now, forty years after the reform and opening-up, China's urbanization has slowed down significantly, and the development of new towns has long been nothing new. However, many new towns are being planned, created, growing, transformed, or slowly dying. Some policymakers and urban planners put many resources into constructing new towns but ignore the difficulties faced by the development of new towns, secured by the elusive blueprint of successful development in the future. This makes people think: about how to solve the problems of new cities, which are supposed to promote urbanization, and how will the potential contribution of the new town to economic and urban development play out.

Under the wheel of history, countless cities have been born, died or were reborn. In a city, the space on the ground is limited, but the total population is increasing, and the scarcity of resources brings all kinds of urban problems. Throughout history, many city builders and urban planners have sought to find the best solutions for the longevity of their cities. It seems to be a long-standing consensus to demand space resources from the sky, and many skyscrapers are rising, but these spaces are still far from enough to solve the dilemma urban development faces. It was not until the late 19th and early 20th centuries that Arturo Soria y Mata, Eugène Hénard, Le Corbusier and others considered the use of underground space to solve the problems of urban development. Underground space, with its unique characteristics and functions, gradually came into the general public's view, especially urban builders.

Underground space is a naturally occurring or artificially developed spatial place in

the earth or rock below the earth's surface, and it is considered one of the most valuable natural resources that have not been fully exploited and utilized by humankind because of its great potential to be excavated and provide space for people. In 1990, the International Tunnelling and Underground Space Association (ITUA) put forward the following draft policy declaration on underground space in terms of regulations, formally adopted in London, UK, in 1991, with the following statement.

"(1) Underground space is a valuable natural resource for human beings. Like land and mineral resources, the development and utilization of underground space should be carefully planned to ensure that this resource is not destroyed or wasted.

(2) The use of underground space is irreversible. Once developed and formed, the land will not return to its original state, and these characteristics require extra attention to the planning of underground space.

(3) To provide reserved space for more critical uses in the future, it is necessary to decide the priority use of underground space. To better deal with the conflicts that may occur, countries and regions should develop relevant guidelines, standards and classifications." (Underground Space Policy Statement, 1991, p.6-8)

Nowadays, there are various theories and practices of solving the urban problems of existing cities through underground space, and some of them do work well. If the development of underground space can solve the problems of old cities, perhaps the dilemmas faced by new towns can also be solved through underground space. Therefore, the research question of this thesis is how to develop underground space to alleviate the ills of Chinese new towns and stimulate the advantages of new towns.

To better understand this issue, it was first necessary to understand the context in which the topic arose - Chinese urbanization, discussed in Chapter 1. Through extensive literature, policy review, and case studies, it was explored how the central government and local governments at all levels determine the direction of urbanization in China and what role the market plays in this process. It also discussed the characteristics of China's urban transformation, including how cities expand, the creation and development of new towns,

the changing urban-rural dichotomy, and informality in urbanization.

After introducing Chinese new cities in Chapter 1, Chapter 2 began with a detailed analysis of the legislative process of Chinese new towns through an extensive policy review to understand the institutional context of new town development and the direction of development. The author then discussed the contribution of new towns to urban development, especially in terms of population, economy and urban space. In addition, the dilemmas faced by new towns were analyzed with examples and data. The role and problems of new towns are directly related to the subsequent focus of underground space development.

In order to discuss specific measures for underground space development in new towns in China, this thesis took Nanqiao new town as a case study. Nanqiao new town is a typical example of a new town that has been upgraded from a development zone to a comprehensive city in the process of urbanization in China. While this new town has the economic advantages of the previous industrialization, it also faces many similar dilemmas, such as excessive land planning, destruction of the ecological environment, and infrastructure that cannot keep up with people's needs. The development of Nanqiao new town shows the commonality of some new towns in China so that the final research results will be informative and generalizable. This thesis used secondary data analysis and fieldwork to understand the current situation of underground space in Nanqiao new town. The analysis also forecasted the scale of future underground space development in Nanqiao new town by land use classification. Finally, the suitability assessment was conducted for the natural environment and socio-economic conditions of underground space development in Nanqiao new town. After referring to reasonable weights, software such as ArcGIS was used to locate the underground space development location in Nanqiao new town. These contents are covered in chapters 3 to 5.

After determining the scale and location of the underground space development, it discussed what functions to assign to the underground space and what development model to implement to alleviate the difficulties encountered by the new town, and others play its

positive role. In Chapter 6, the author first suggested developing underground space in the core area of the new town to stimulate the development of the new town and promote the intensive and efficient use of urban space; then, in terms of functional positioning, based on the advantages and characteristics of underground space, try to strengthen the multi-functional use of underground space in the new town and reduce the waste of resources; implement the construction of environmentally friendly underground space to give full play to the advantages of less pollution from underground facilities and minor damage to surface vegetation; and Finally, the connectivity of underground space is strengthened to provide the basis for subsequent new town development.

The last part is the conclusion of this thesis. The author summarized the contents of the previous section and pointed out the parts that this thesis failed to cover, such as the influence of the economic strength of new towns on the development of underground space. This could also be one of the directions for future research.

Chapter 1 China's urbanization process

Unlike urbanization under the role of the market economy, China's urbanization is centered around government action, which has contributed to the uniqueness of China's urban transformation.

1.1 The role of the government in the urbanization process

In China's urbanization process, the government plays a crucial role. In developed countries with market-based economies, the role of the government in economic development is mainly to guarantee the operation of market mechanisms and to carry out macroeconomic regulation, without directly participating in the market competition or interfering with the behavior of economic agents (Wu, 2014). Therefore, urbanization in developed countries occurred and evolved mainly under the domination of market mechanisms, for example, the rapid urbanization in England and Wales originated from the industrial revolution at the end of the 18th century, and from 1801 to 1891, the proportion of the urban population in these two regions jumped from 17% to 54% (Watson, 1993). However, the situation in China is very different. After the founding of New China in 1949, the government implemented a highly centralized planned economic system in which all aspects of economic development were decided by the central government, the production and operation of enterprises and the migration and mobility of individuals were strictly controlled by the state plan, and local governments had no incentive to develop the economy; therefore, urbanization was very much lagging. After the reform and opening up (1978)[1], the gradual implementation of the market economy system, with the decentralization of the central government, has greatly stimulated local governments, enterprises, and individuals

[1] The reform and opening-up or Chinese economic reform; known in the West as the Opening of China is a policy of domestic reform and opening to the outside world that the People's Republic of China (PRC) began to implement in the Third Plenary Session of the Eleventh Central Committee in December 1978. It is a program of economic reforms termed "Socialism with Chinese characteristics" and "socialist market economy". Led by Deng Xiaoping.

to compete in the market, thus promoting the influence of enterprises and individuals on urban development (Ning, 1993).

During this period, the central government's urbanization policy played a leading role, while local governments formulated detailed policies based on the actual situation in their jurisdictions and promoted their implementation. Driven by the central government and local governments at all levels, China's urbanization rate has increased rapidly. From 1953 to 2020, China's urbanization rate has jumped from 13.26% to 63.89% (National Bureau of Statistic,2021) (Figure.1).

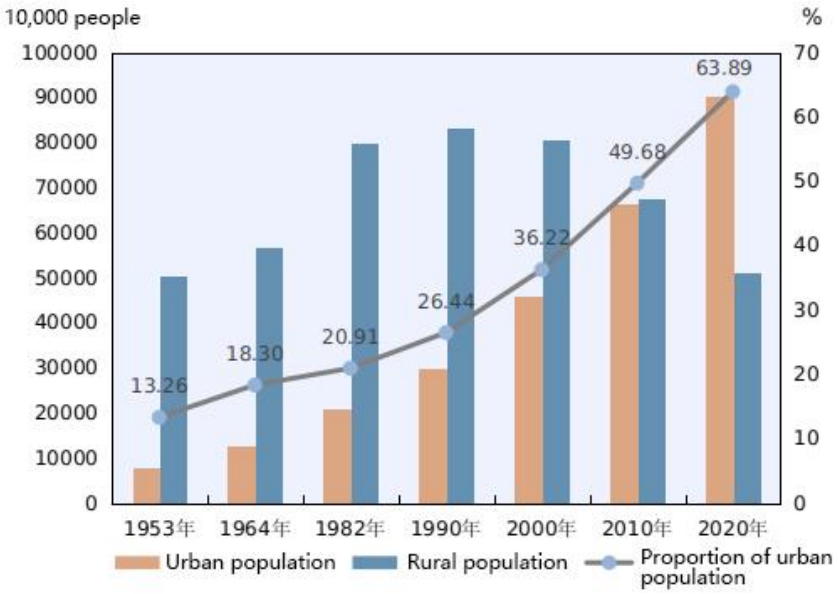

Figure 1 - China's urbanization rate, 1953-2020
Source: National Bureau of Statistic,2021. http://www.stats.gov.cn/

1.1.1 Central government policies

Before the reform and opening up, the central government also made attempts to decentralize power. In April 1956, Mao Zedong proposed in his article "On the Ten Relations" that local governments should be decentralized, mainly including local planning power, enterprise jurisdiction, material distribution power, labor-management power, financial and taxation power, investment and credit approval power, etc. (Zhang, 2007), but

due to the influence of political movements such as the Great Leap Forward[2], this idea was not implemented and the process of urbanization in China remained slow.

To promote urbanization, the central government formulated direct policies such as making urban construction the focus of national development, and also adopted policies such as economic system reform, decentralization, and adjustment of the hukou registration system to promote urbanization indirectly

(1) Policies on urban construction

Starting from the reform and opening up, the central government recognized the great strategic significance of urbanization and the urgency of developing urbanization, and explicitly proposed new strategies and policies on urban development, which had a direct role in promoting China's urbanization. In 1987, the 13th National Congress of the Communist Party of China emphasized the role of cities, especially to build large and medium-sized cities into multifunctional, modern economic centers. In 1992, the 14th National Congress proposed to develop the Pudong New Area and to build Shanghai into an international economic, financial and trade center. In 1997, the 15th National Congress emphasized the construction of small cities. The successive five-year plans from 1985 onward have also had a similar guiding effect on urban development and have proposed more specific guidelines for action.

In the 21st century, a series of urban and rural problems such as the occupation of farmland, waste of resources, environmental damage, and urban sprawl have led China to focus on the quality of urbanization instead of simply pursuing quantitative changes.

[2] The "Great Leap Forward" movement refers to the mass movement that China carried out during economic construction from 1958 to 1960, with the main feature of achieving high industrial and agricultural production targets. This movement is a serious setback for the Communist Party of China in the process of exploring the road to building socialism. The "Great Leap Forward" disrupted the order of the national economy, wasted a lot of manpower and material resources, and caused a serious imbalance in the proportion of the national economy.

In 2000, China implemented a new "land quota" policy, which allows for the exchange of urban and rural construction land. Within the jurisdiction of local governments, if a certain amount of agricultural land was reclaimed in rural areas, the same amount of land could be added to the construction land quota in urban areas (MLR 2000; State Council 2004). This policy promotes the rational development of urbanization based on the protection of arable land. The Seventeenth National Congress (2007) proposed the formation of urban agglomerations with large jurisdictions based on mega-cities and the cultivation of new economic growth poles. The concept of urban clusters in China is similar to the city region studied by Western scholars (Harrison, 2014). As a result of economic agglomeration, several cities close to each other are formed into urban clusters to promote urban development in the region through top-down cooperation, planning, and governance between cities, and to curb overcapacity, excessive infrastructure, and environmental degradation to a certain extent (Li, & Wu, 2018). Currently, the Pearl River Delta, the Yangtze River Delta, and the Beijing-Tianjin-Hebei (Jing-Jin-Ji) region are some of the faster-growing urban agglomerations in China, and the Nanqiao new town explored in this thesis is within the Yangtze River Delta region.

In 2012, the 18th National Congress proposed a new type of urbanization strategy, and in November 2013, *The Decision of the Central Committee of the Communist Party of China on Several Major Issues of Comprehensively Deepening Reform* pointed out that "we will adhere to the new type of urbanization road with Chinese characteristics and promote urbanization with people as the core." (State Council, 2013). High-quality and livable urban development has become the core of China's urban development at this stage. The new urbanization also means the transformation and upgrading of new towns. In response to the development zone fever of the last century, the state adjusted the preferential policies of development zones, especially requiring the cleanup and consolidation of development zones, so that the number and scale of development zones have been sharply reduced and have been transformed into comprehensive new zones (Zhu, & Zhou, 2013). In the face of the former high energy-consuming, high-polluting industrial new towns, local governments

seek to upgrade their industries and promote the development of resource-saving, green, and sustainable-oriented new towns. The core of new urbanization is population urbanization (Wu, & Sun, 2018). In China, population urbanization is a concept that is different from land urbanization. It refers to the process of changing from agricultural to non-agricultural population as a result of the transformation of agricultural population into non-agricultural population and the transformation of rural areas into urban areas, which in essence should be the process of transferring the economic activities of the population. Since the household registration system has lagged behind the radical urban construction policy, the corresponding conversion of the agricultural population into urban population has been slow, although the land for urban construction is rapidly increasing. China's population urbanization rate tends to lag behind the land urbanization rate by about ten percentage points. To ensure the smooth urbanization of the population, the Fifth Plenary Session of the 18th Central Committee in 2015 proposed that "about 100 million migrant workers and other permanent residents should settle in cities and towns". (State Council, 2015). In 2017, the 19th National Congress proposed “a housing system with multiple main bodies of supply, multiple channels of protection, and rental and purchase.” (State Council, 2017). In the same year, *The National Land Planning Outline (2016-2030)* formulated a long-term strategic plan for the land supply structure and utilization pattern. The urban and rural land system is used to facilitate the urbanization of the population by matching population mobility.

In the new 14th Five-Year Plan in 2021, emphasis is placed on improving the spatial layout of cities and enhancing the quality of cities in general. On the one hand, the development and growth of urban clusters and metropolitan areas, classification to guide the development direction and construction priorities of a large, medium, and small cities, and to form a sparse and dense, collaborative, functional urban spatial pattern. On the other hand, China will accelerate the transformation of urban development, coordinate urban planning and construction management, implement urban renewal actions, promote urban

quality improvement, and build cities that are livable, innovative, green, humanistic, and resilient.

So far, the central government has planned a more comprehensive blueprint for China's urban construction.

(2) Policies on economic development

China's urbanization had finally entered a period of rapid development through the implementation of urban construction and development policies decreed by the central government. On the other hand, the economic development policies decreed by the central government provide a lasting impetus for urbanization. Economic development is an important driving force of China's urbanization, in line with the general rule of urbanization in the world. But China's economy has deep roots in political economy in nature, and its development is subject to macro-regulation by the government. In China, the government is the main body of the market economy. Under the premise of respecting market regulation, the government promotes a balanced economic structure and sustainable economic development through administrative and economic means (mainly fiscal means). The central government promotes economic development through policies that indirectly strengthen urbanization. Beginning in the 1980s, China used the installation of new productive urban zones as a strategic plan to promote economic development and urbanization. By the end of the 20th century, China had formed special economic zones, high-tech zones, bonded zones, and border economic cooperation zones, which were based on the main urban areas and took advantage of policy preferences such as tax and land to become modern industrial new towns (Zhu, 2013). In terms of taxation, these zones had the authority to approve statutory income tax exemptions and reductions; local income tax, tax reductions and exemptions for indirect investment income; the authority to levy and reduce the industrial and commercial flat tax on products; and the authority to periodically reduce and exempt the industrial and commercial flat tax on non-productive enterprises. In terms

of land, the policy provided greater flexibility in the use of land in the Special Administrative Region. Land titles in the zones could be freely transferred under legal regulation, and an increasing proportion of land could be offered through market methods (auction, tender, market price agreement). The land market in the zones played an extremely strong role in the allocation of land resources than in the main urban areas.

In 1980, the 18th session of the Fifth National People's Congress[3] decided to approve the State Council's proposal to establish Shenzhen, Zhuhai, Shantou, and Xiamen in Special Economic Zones, in which Shenzhen quickly became one of the most economically developed cities in China from a small fishing village a century ago. The Shanghai Pudong Economic Development Zone, established in 1990, has developed very rapidly(figure.2). The Pudong New Area has not only improved the quality of urbanization in Shanghai but has also led to an increase in urbanization rates in the neighboring provinces of Jiangsu and Zhejiang. From the central government to the provincial government to the municipal governments have the power to set up new zones and develop new towns. Local governments have incorporated urbanization and urban development as important political achievements to promote development within their regions, and local governments compete not only for economic performance but also for urban development (Li, Chen,& LIu, 2012). Conflicts can arise between governments in intercity regions as they compete for development resources, which requires coordinated planning at the highest level of government (Li, 2018). The construction of new industrial cities has promoted urbanization in China, but the development zone boom of the 1990s also caused problems such as wasted resources and urban sprawl.

[3] The National People's Congress of the People's Republic of China is the highest organ of state power. The National People's Congress and the Standing Committee of the National People's Congress exercise state legislative power. The term of office of the National People's Congress is five years. The National People's Congress meeting is held once a year and is convened by the Standing Committee of the National People's Congress. The National Congress of the Communist Party of China and the Central Committee it produces are the highest leading organs of the Communist Party of China. According to the Party Constitution, the National Congress of the Communist Party of China is held every five years and is convened by the Central Committee.

Figure 2 – Location map of Shenzhen, Zhuhai, Shantou, Xiamen Special Economic Zone and Shanghai Pudong Economic Development Zone

Source: Elaboration by author

Market dynamics are the natural driving force of urban development, and the economic system reform has stimulated the dynamics of China's economic development and thus urbanization. Prior to the economic reform, China had an absolutely planned economic system that inhibited urban development. After the end of the socialist transformation in 1956, a planned economic system was basically formed, combining the Soviet experience and the actual situation in China. The core of this system was the institutional framework of political and economic integration, in which enterprises became subordinate to and extensions of the state power, and localities lacked the necessary autonomy and independence. Under the planned economy, the allocation of resources, including what and how much to produce, was determined by government plans. In the early years of New China's development, the planned economy was effective in curbing inflation, stabilizing the economic development environment, and establishing a basic national social welfare system.

However, because of the balanced strategy and the fixed allocation of resources, localities lacked the incentive to develop the economy, and thus urban development lost its momentum and vitality. During this period, China's urbanization process showed low-level fluctuations or even regression. In the later part of the planned economy period, China experienced a crisis of economic backwardness, backward urban development, increased financial burden on the state, and wasted resources. This was the time when economic system reform was urgently needed to release the market economy dynamics.

Compared with the rigid centrally planned economy, the reform has led to a significant decentralization of economic power, and China has entered a transitional period in which planning and market co-exist (Wu, 1999). In 1992, Deng Xiaoping's Southern Tour speech pointed out that both the market and planning are means of economic development and made a clear strategic decision to establish a socialist economic system with Chinese characteristics; then in 2013, the 18th National Congress of China decided to deepen the reform of the economic system and that the market plays a decisive role in the allocation of resources. The reform of China's economic system was reflected in the implementation of the joint production responsibility contract system in rural areas, which quickly mobilized the enthusiasm of both farmers and the community at the management level and led to the speedy development of agricultural production, which provided the material basis for the development of urbanization, while the increase of rural productivity created surplus labor. On the other hand, the reform of state-owned enterprises in the cities, where the enterprises had certain independent property and management rights, and gradually began to separate the government and enterprises, released the motivation of the enterprises. The rise of foreign investment also led to strong economic development in the cities, attracting a large number of rural laborers to work and live in the cities.

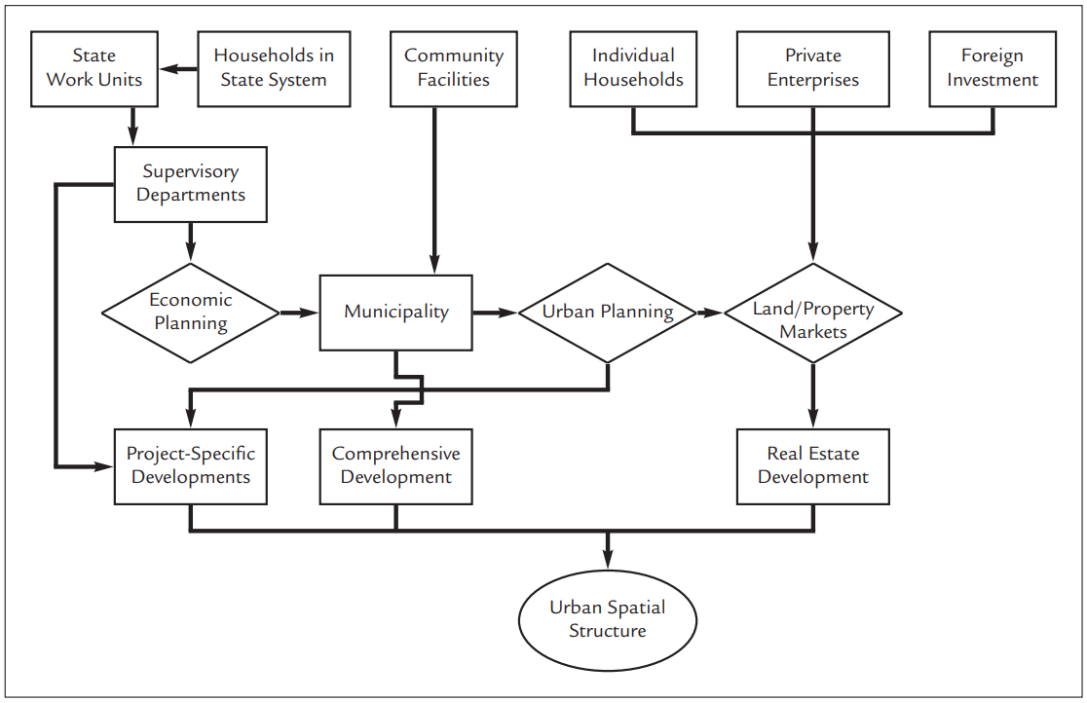

Figure 3 - Urban development process in the centrally-planned economy of China before economic reform in1978.

Source: Wu, F.L,1999. Urban Spatial Structure in a Transitional Economy

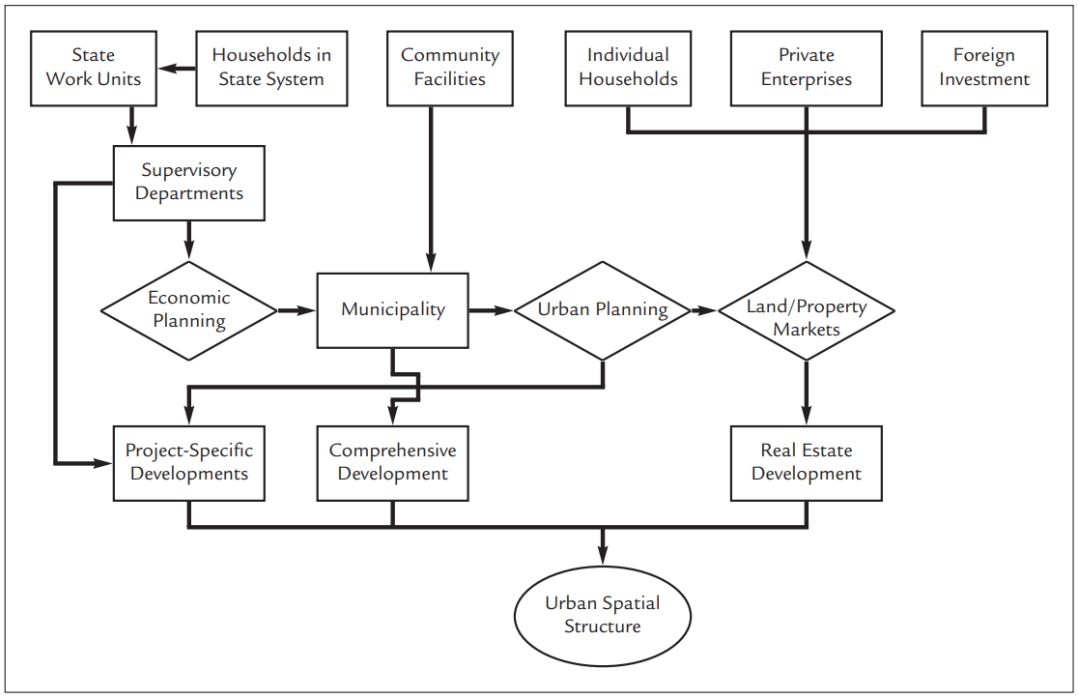

Figure 4 - Urban development process in the transitional economy of China after economic reform in 1978.

Source: Wu, F.L,1999. Urban Spatial Structure in a Transitional Economy

(3) Decentralization reform

The decentralization reform of the central government was also the main reason for accelerating urbanization. Power was devolved to local governments, especially municipalities and urban districts, and with the reduced involvement of state agencies and inspection departments, a series of decentralization policies allowed local governments to begin to play a more active role in urban development (Wu, 1999). The reform of the land system in 1987 and the housing system beginning in 1999, which marketized land and housing, led to dramatic changes in the organization of urban development in China (Chiu, 1996; Wu, 1996; Zhou & Logan, 1996).

The land reform made it clear that land-use rights could be transferred according to the law (Constitution, Land Management Law, 1988), and that a system of "bidding and auctioning" was implemented for business land (State Council, Circular on Strengthening the Management of State-owned Land Assets, 2001). The reform of the land system has led to the separation of land ownership and land use rights, with land still owned by the state, but with local governments becoming the administrators of state land. Local governments could get a lot of money for various kinds of urban construction through land concessions, and at the same time, the land concessions were rapidly acquired for construction, so urban construction developed fast. However, the less restrictive land concessions also led to the problem of urban sprawl and the encroachment of precious farmland resources, which is not conducive to future sustainable development (Wu, 1999).

During the planned economy, China's urban units were distributed in kind under the public ownership system, and housing reforms led to the withdrawal of state-owned enterprises from direct housing production. In the 1990s, the central government proposed to "comprehensively promote housing market reform, actively implement the commercialization of urban housing, and accelerate the development of the civil construction industry to make it a pillar industry of China's national economy".

Subsequently, the People's Bank of China, the Ministry of Finance, the State Administration of Taxation, and the Ministry of Construction issued a series of stimulus policies to encourage individuals to buy and exchange housing. Local governments responded positively and invested in urban housing construction, especially the construction of commercial houses (Ding, 2013). The amount of real estate investment rose from 317.8 billion yuan in 1997 to 147,602 billion yuan in 2021, an increase of more than 40 times (Figure.5). In the process of real estate development, local governments can obtain high revenues, including large amounts of taxes and land concessions. According to the report of China's Ministry of Finance in 2021, the country will collect 205.8 billion yuan in urban land use tax, 646.8 billion yuan in land value-added tax, 284.2 billion yuan in property tax and 706.1 billion yuan in deed tax in 2020.The high revenue that local governments can obtain in the process of real estate development has therefore driven them to build a large number of urban housing units, further promoting urbanization.

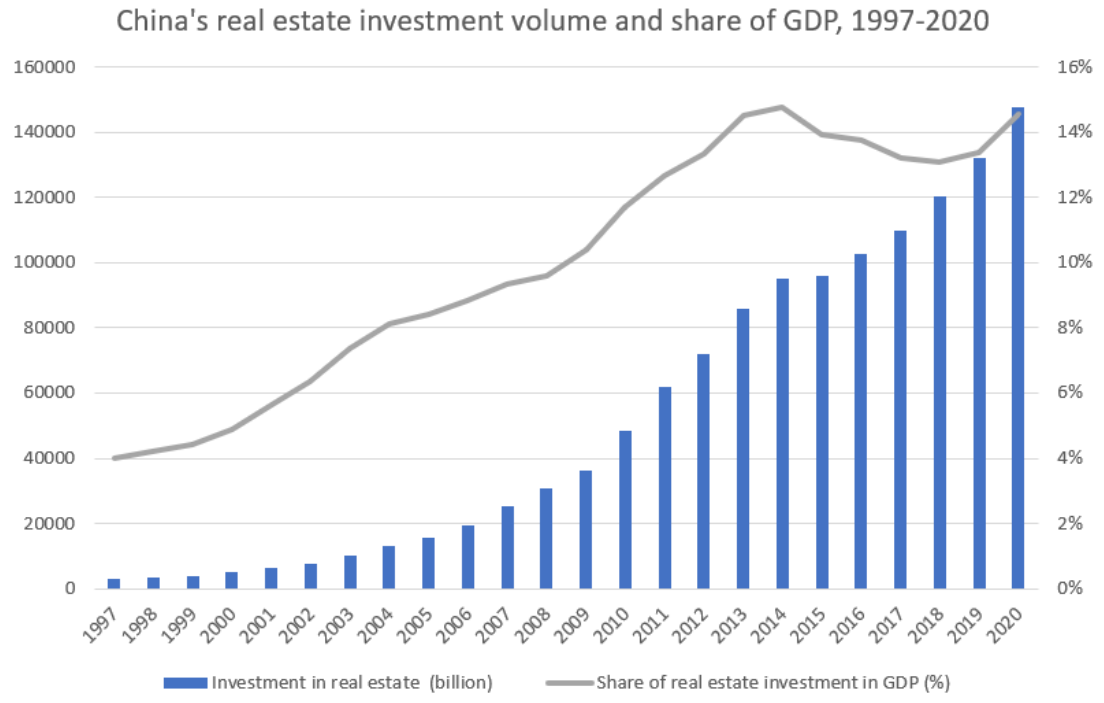

Figure 5 – China's real estate investment volume and share of GDP, 1997-2020

Source: Elaboration by author with data from National Bureau of Statistic,2021.

http://www.stats.gov.cn/

In addition, with the decentralization of local governments after 1978, the local governments had more revenue at their disposal and became more active, and the reform of the fiscal and taxation system in 1994 divided the central government and local government revenues according to tax types so that most of the land concessions and real estate-related taxes and fees went to local governments, which laid the institutional foundation for local governments to vigorously develop real estate and gain benefits from land concessions.

(4) Policies on social management

In terms of social management, initially, to prevent and catch counter-revolutionaries and criminals, a strict hukou system[4] prohibited the movement of the population, forming a dualistic social model of urban and rural areas. It was only after the reform and opening up that the control of population movement was gradually liberalized to promote the normal movement of labor (Chen, 2011). From 1984, The Notice of the Central Committee of the Communist Party of China on Rural Work 1984 allowed peasants who worked, did business, and ran their rations to settle in cities, to 2013, The Decision of the Central Committee of the Communist Party of China on Several Major Issues of Comprehensively Deepening Reform, which "comprehensively liberalized the restrictions on settling in established towns and small cities, orderly relaxed the restrictions on settling in medium-sized cities, reasonably determined the conditions for settling in large cities and strictly controlled the population of megacities. The size of the population of mega-cities will be strictly controlled". The role of the household registration system reform on urbanization is mainly reflected in the provision of a large amount of rural labor for urban industrial development, expanding the size of the urban population, but the drawbacks of the

[4] A hukou is a legal document created by the administrative authorities in charge of household administration in mainland China to record and retain the basic information of the resident population. It is also a proof of identity for every citizen. The hukou is a public certificate book that registers and certifies natural persons by household, recording matters such as their names, dates of birth, relatives, and marital status.

household registration system still exist, a large number of rural laborers employed in the city, but can not settle in the city, forming a temporary population (Wu, 2014).

1.1.2 Local government policies

The central government sets the overall institutional and policy framework for urbanization, but urbanization in China exhibits regional differences, which have a large relationship with the behavior of local governments. How local governments implement the central government's policies and formulate policies within their jurisdictions directly affects the process of urbanization in China. With the central government's urbanization system and policies as the axis, local governments will take measures such as administrative zoning adjustment, institutional innovation, policy preferences, and establishment of development zones in order to seek better urbanization. However, different levels of local governments have different authority to make policies and act, which also leads to differences in urbanization within each region, especially within a province.

Different localities have different natural, economic and human environments, and despite local governance under a unified framework from the central government, local governments have considerable autonomy within their jurisdictions. In China, local government refers to all levels of government relative to The Central People's Government, including provincial, prefectural, county and township-level administrative regions. Provincial-level administrative regions include 23 provinces, 5 autonomous regions, 4 municipalities directly under the Central Government and 2 special administrative regions. The prefecture-level administrative regions include 293 prefecture-level cities, 7 regions, 30 autonomous prefectures and 3 leagues. County-level administrative districts include 977 municipal districts, 1303 counties, 393 county-level cities, 120 autonomous counties, 49 banners, 3 autonomous banners, 1 special district (this special district refers to county-level administrative districts with a special concentration of industrial and mining enterprises, not special districts in China's urbanization process), and 1 forestry district. Township-level

administrative districts: 8,562 streets, 20,988 towns, 8,102 townships, 966 ethnic townships, 153 soums, 1 ethnic soum, and 1 county-level district (NBS, 2021). In addition to this, since the reform and opening up, China has established seven special economic zones. Special Economic Zones (SEZs) implement more special and flexible economic policies, economic measures and economic management systems than other administrative regions. This leads to a different urbanization process in the SEZs than in the macro-level local administrative regions. Therefore, this thesis described the policies and implementation methods of different levels of local governments and SEZs.

(1) Administrative zoning

The essence of administrative zoning is the spatial expression of the administrative system; therefore, the impact of administrative zoning adjustment on urbanization development is precisely the expression of governmental system reform to promote urbanization development (Wang, 2009). In the restructuring of provincial governments, it mainly includes the upgrading of counties to prefecture-level cities; the merger of regions with prefecture-level cities; and the transformation of a county into a district of a prefecture-level city. In the restructuring of prefecture-level government, it mainly includes several types of township mergers, townships becoming a district of a prefecture-level city, counties under municipal control, and administrative level upgrades (Wu, 1015).

Administrative zoning changes have had a large impact on urban development. It is estimated that from 1990 to 2005, a total of 99 prefecture-level cities and municipalities directly under the central government were added through the "merger of districts and prefecture-level cities" and the "merger and upgrading of counties to prefecture-level cities"; a total of 328,000 square kilometers of urban area were added. 14 cities The increase in size is due to the zoning change of "a county into a district of a prefecture-level city" (Qu, 2009).

Administrative zoning adjustments directly contribute to the scale of urbanization, provide institutional safeguards for the expansion of China's large cities and megacities, and

reduce the administrative costs of urban operation. In addition, it provides space for upgrading and reorganization of urban functional areas, which is conducive to improving urban competitiveness. It reduces the management level and promotes the flow and reasonable concentration of factors; it promotes the transformation of government functions and the innovation of government management system (Wang et al., 2008; Zhang et al., 2002). However, without scientific proof and intrinsic needs, administrative restructuring not only does not promote urban socio-economic development, but also causes political and economic fluctuations due to the drastic changes in administrative boundaries, which will cause more harm to the economic vitality of the county (Wang, 2003).

(2) Institutional innovation

In the context of the central government's system reform, local governments can interpret and implement the central policies to meet local needs in order to meet the needs of local development, or they can select points in their own jurisdictions for experimentation and then promote them after success. Local governments have three main approaches to institutional innovation: 1. taking the initiative to carry out institutional innovation within their own jurisdictions; 2. acting as agents of the central or higher governments to experiment with institutional innovation within a certain institutional framework; 3. encouraging and supporting the institutional innovation activities of micro-institutional subjects so that institutional innovation can be realized (Liu, 2009). Compared with the central government's institutional reform, local government's institutional innovation is characterized by microscopic, practical, experimental and marginal nature (Chen, 2013).

According to the local government behavior in the urbanization process since the reform and opening up, local institutional innovation mainly includes administrative system innovation, land system innovation and household registration system innovation.

a. Innovation of administrative system: to further increase local motivation by expanding the autonomy of lower-level governments. Within the framework of the traditional administrative system, provinces administered cities, cities administered counties, and counties administered lower-level commune-level administrative districts. Through decentralization, the provincial government can directly manage the counties, while giving the county governments more autonomy, allowing them more room to play in economic development and social management functions. Such an administrative system innovation has been adopted mainly by provincial governments, eliminating the management of prefecture-level governments, and the reduction of administrative management levels and administrative costs has facilitated county-level governments to carry out urban development projects. Zhejiang Province's expansion of county powers is the earliest example. Zhejiang not only expanded the power of counties, but also expanded the power of some municipalities.

As early as 1992, in order to "converge with Shanghai economically," Zhejiang expanded the powers of 13 counties (cities) with rapid economic development, expanding the powers of approval for capital construction, technological transformation and foreign investment projects. 1997, Zhejiang further experimented with the economic management authority of some prefecture-level cities in Xiaoshan and Yuhang counties (cities), and the strength of the expansion was significantly increased. In 2002, Zhejiang delegated 313 approval powers to 17 economically strong counties (cities) such as Shaoxing, Wenling and Cixi, delegating the economic management authority at the prefecture level directly to the counties (cities). Since 2007, Zhejiang and the implementation of strong township expansion strategy, selected 141 provincial-level central town, giving part of the county-level economic and social management authority. In this series of decentralization measures is to get rid of the redundant and inefficient management system of urban-rural relations, accelerate the transition from "urban-rural separation" to "urban-rural integration" of the management system, and promote the development of urbanization in Zhejiang Province. Some economically strong counties have taken the lead in economic development by relying on

the radiation function of big cities. Some counties without location advantages, such as Yiwu, the development of a little slower, but eventually formed their own "obligatory business circle" to play the agglomeration and radiation function of the metropolis. 2007, Yiwu market to the surrounding counties and cities to export processing industry business value of more than 10 billion yuan, driving the surrounding areas more than 300,000 rural surplus labor Engaged in small commodity processing business (National Bureau of Statistics, 2007). Driven by the administrative system of expansion in Zhejiang Province, from 1988 to 2007, the obligation developed from counties to cities, and the urbanization level soared from 15% to 63&, higher than the provincial average of 57.2% (National Bureau of Statistics, 2008).

b. Innovation of land system: Before the central government's land system reform in 1988, local governments had already started to try to innovate the land system for economic development; after 1949, China established the socialist public ownership of land, and the constitution clearly stipulated that "no organization or individual shall appropriate, buy, sell, rent or otherwise illegally transfer land. " This led to the main features of the old state-owned land use system: first, land was used without compensation, second, it was used indefinitely, and third, it was not allowed to be transferred. The failure to treat the ownership and use of land separately resulted in the uncompensated occupation of land and the repeated occupation and over-occupation of land, resulting in a great waste of land resources. The Shenzhen SAR government was the pioneer of China's land system reform.

The biggest constraint in the early stage of reform and opening up was the lack of capital. At that time, the state's policy principle for the Special Administrative Region was "only give policies but not money". In 1980, when the construction of Shenzhen Special Economic Zone was about to start, the large-scale infrastructure construction was faced with a severe shortage of funds, and apart from the 30 million yuan loan from the bank, no more funds could be financially produced. The Shenzhen Special Economic Zone government had no choice but to break through the constraints and start the attempt to transfer the land use rights for compensation. In March 1979, Shenzhen leased 1,000 mu of land in Shekou

Peninsula to Hong Kong Merchants for the construction of Shekou Industrial Zone. Shenzhen's attempt to transfer the right to use land for a fee was an innovation. When developing the Luohu district in Shenzhen, the government estimated that at least 400,000 square meters of land could be used as commercial land, and at HK$5,000 per square meter, the government could obtain HK$2 billion in revenue to finance the development of infrastructure. The Shenzhen SAR government, perhaps with the tacit approval of Mr. Deng Xiaoping, was the first to experiment with the system of using state land for compensation. 1982 saw the promulgation of the *"Temporary Provisions on Land Management in the Shenzhen Special Economic Zone"* (hereinafter referred to as the *"Provisions"*), which reformed the use of allocated land for compensation and a fixed period. The *Provisions* also described the length of use of various types of allocated land and the criteria for land use fees. It was not until 1987 that the National People's Congress officially wrote the transfer of state-owned land use rights with compensation into the Constitution. Shenzhen's urbanization was greatly enhanced by the innovation of land system to efficiently use land to build industrial zones and promote economic development.

In addition, Shenzhen SAR started land acquisition internally in 1980, initiating the road to de-agriculturalization by expropriating whole villages of land at less than 50 yuan per square meter. In 2004, Shenzhen became the first city in China without rural areas.

c. Innovation of household registration system: according to the resident population, China's urbanization rate was close to 60% in 2018, but due to the existence of the household registration system, the level of China's urbanization rate was less than 45% in 2018 according to the household registration population. Although China's household registration system has been gradually reformed since the 1980s, there is still a lot of room for it. The key to the hukou system is the social welfare system associated with the hukou, so reforming the hukou system needs to go hand in hand with other reforms such as equalization of public services. The goal of the reform should be to gradually abolish the benefits associated with the household registration, promote the reasonable movement of

the population, and guarantee the right to move. Innovation in the household registration system is a means for many provincial and municipal governments to attract talent and promote urban development.

According to many provincial governments, the conditions for household registration migration are more lenient than the national version. For example, starting from 2016, the Shaanxi provincial government has relaxed its household migration policy including: rural household registration population can apply for household settlement if they have been employed and living in the city for more than one year; in addition, the household migration policy of freedom to come and go is implemented in rural areas; the conditions for settling in the category of dependency are relaxed; and the household settlement policy in Xi'an is adjusted and improved, i.e., a point-based household settlement system is established and a differentiated household settlement policy is classified. From then on, the urbanization rate of household registration population in Shaanxi Province will increase by more than 1.5 percentage points per year, with an average of 3.5 million household transfers per year. By 2020, the urbanization rate of Shaanxi's household population will reach more than 50% (Shaanxi Provincial Government).

Some local governments are not shy, and since early 2017, Xi'an, the capital of Shaanxi Province, has also issued new policies to lower the threshold of household registration, such as lowering the number of years of social security payment and continuous residence, reducing the submission of materials for housing purchase, and preferential settlement for rural students, military personnel, and migrant workers, etc. In 2018, the settlement process was simplified. The annual household population in Xi'an jumped from an average of less than 80,000 before to 200,000 in 2017, and increased significantly by nearly 780,000 in 2018. By 2020, the urbanization of Xi'an's household population reaches 68.2% (Xi'an Municipal Government). This shows that for large cities that are themselves well developed, prefecture-level governments can further promote population urbanization and improve urban development through innovations in the household registration system.

(3) Policy preference

The degree of policy preference is compared out, whether it is a comparison between local government policies and central government policies, or a comparison of policies among local governments. The preferential policies arise from the competition among local governments for various factors of production needed for economic development in each region. In the context of economic globalization, the competition for production factors such as talents, technology and capital is becoming more and more intense.

In the early stage of reform and opening up, due to the limited capital, foreign capital became an important force to rely on in China's economic development, so a series of preferential measures were formulated to attract foreign investors to settle in the country, and the *"Regulations of the State Council on Encouraging Foreign Investment"* was issued in 1986, with the policy content mainly providing "super national treatment". After the central government implemented the strategy of introducing foreign investment, each local government formulated its own policies to attract foreign investment and strengthen the use of foreign investment. For the competition of talents, in December 2008, the central government issued the *"Opinions of the Central Coordination Group for Talent Work on the Implementation of the Plan for the Introduction of Overseas High-Level Talents"*, which guided the introduction of talents from the central level and significantly increased the intensity of the introduction of talents. Local governments soon introduced the "Thousand Talents Plan" and "Hundred Talents Plan" in various places. Local governments provide good conditions to attract high-level talents in terms of salary and income, housing and development opportunities.

In Jiangsu Province, for example, in 2017, the Jiangsu government issued the *"Opinions of the Provincial Government on Several Policies for Expanding Foreign Opening and Actively Utilizing Foreign Investment"*. These include relaxing restrictions on foreign

investment access in various industries, providing better infrastructure, offering incentives to staff and departments for the introduction of foreign investment, exempting some foreign investment projects from tariffs, and supporting overseas high-level talents to start and develop businesses in Jiangsu. According to the document of Jiangsu Development and Reform Commission, the actual utilization of foreign investment in Jiangsu Province in 2020 was 28.38 billion U.S. dollars, an increase of 8.6% year-on-year, and the scale of utilization of foreign investment accounted for 1/6 of the country. The scale of utilization of foreign investment in Jiangsu Province also continued to exceed the provinces and municipalities such as Guangdong (25.42 billion U.S. dollars), Shanghai (20.23 billion U.S. dollars), Shandong (17.65 billion U.S. dollars), Zhejiang (15.78 billion U.S. dollars).

At the early stage of reform and opening up, Jiangsu Province rapidly developed its industrial economy through the introduction of foreign capital, built several processing and production bases, and formed industrial agglomeration. The industrial agglomeration implied a large demand for labor, which was continuously transferred from rural to urban areas, solving employment and promoting urbanization at the same time (Sun, 2010). To maintain the inflow of foreign capital, the Jiangsu government has continuously introduced various preferential measures, such as upgrading infrastructure, to optimize the quality of urbanization in another step. By the last two decades, the Jiangsu government has supported foreign firms to improve their technological innovation capabilities and drive technological innovation in local firms (Zhao, 2014). The result of foreign and local firms competing with each other for development is a continuous inflow of talents into Jiangsu and an increasing urbanization of the household population. in 2020, the urbanization rate of the province was 73.44%, which is almost 10 percentage points higher than the national average, in addition to an urbanization of 67.3% of the household population.

On the other hand, there are differences in preferential policies among prefecture-level cities in Jiangsu province, among which Nanjing, Suzhou has more preferential policies of municipal governments, attracting more than 40% of foreign investment in the province.

2020 urbanization level of these two cities is also leading in the province, 86.8% and 80% respectively.

Besides, compared to other provinces and cities, Special Economic Zones (SEZs) are areas where China has implemented special policies that are more open and flexible for the development of foreign trade, especially for attracting foreign investment and introducing technology since the implementation of the open-door policy. The charm and vitality of SEZs lies in their "special" status, which is not only the historical status of SEZs as "windows" in the reform, opening up and modernization of the country, but also their role as "experimental zones". In addition to its historical position as a "window" and "experimental zone" in the national reform and modernization, it is also "special" in that the state allows special zones to implement special policies that are different from those of ordinary areas (Wu, 2019). The use of state-granted preferential policies as an initiating mechanism, combined with locational advantages, has been the main reason for the brilliant achievements of China's SEZs over time.

Within the SEZs, preferential conditions are provided to foreign investors in terms of the import of equipment, raw materials and components for enterprises and export of products, corporate income tax rates and exemptions, foreign exchange settlement and remittance of profits, land use, residence and entry and exit procedures for foreign investors and their family members' entourage. Specifically, for example, foreign-invested enterprises and foreign enterprises that set up institutions and premises to engage in production economy; foreign banks, Sino-foreign joint venture banks and other financial institutions; productive foreign-invested enterprises in energy, transportation and port construction projects; service foreign-invested enterprises; foreign-invested enterprises engaged in ports, docks, airports, highways, railroads, power stations, coal mines, water conservancy and other infrastructure and agricultural development operations, etc. are subject to a reduced Income tax is levied at a rate of 15%-50%. At the same time, foreign investors in joint ventures in the Special Administrative Region are exempted from income tax when they remit their profits from the enterprises outside the country.

With the super favorable policy conditions, the cities of the SEZs are developing rapidly, especially Shenzhen, Xiamen and Zhuhai, which will all have urbanization rates of over 90% by 2020.

(4) Establishment of Development Zones

After the central government and the State Council established four special economic zones in 1981, they also approved the establishment of economic and technological development zones in open coastal cities. However, in the early days of reform and opening up, the establishment of development zones required the approval of the State Council, and local governments were not authorized to set up their own zones. In 1988, provincial governments began to have the right to approve the establishment of local development zones. In order to attract foreign investment, develop industry and promote local economic development, provincial governments started to set up development zones. There are three main types of provincial development zones, namely provincial economic development zones, provincial high-tech industrial parks, and provincial special industrial parks. According to the latest China Development Zone Audit Bulletin Catalogue (2018 edition), there are currently 2,675 development zones in China, of which 622 are national-level development zones and 2,053 are provincial-level development zones.

The nature of development zones is an expedient and innovative means of customer service economic and institutional constraints (He & Qian, 2017), and the successful development of development zones can facilitate the urbanization of this region. Taking the Yangtze River Delta as an example, the development zones here have flourished due to preferential policies as well as the foreign investment attracted, internal economic advantages and a unique location (Zhang, 2016). First, policy and external investment factors are the main features of the urbanization dynamics of the development zones in the Yangtze River Delta, i.e., large-scale and intensive investment triggered by macro policies as the core driver of their urbanization. Other factors, such as urban construction policies,

planning policies, land use policies, and internal management system innovation, are also part of the policy forces. Secondly, the expansion of the sector due to the economic strength of the cities in the Yangtze River Delta has led to a rapid increase in the industrial level of the development zones, which in turn has led to the development zones having a corresponding strength base in the first place. Lastly, the Yangtze River Delta is located in a coastal area, which allows for smooth foreign trade. The development zones themselves are located at the edge of cities and at the border between urban and rural areas, with good natural and ecological factors and convenient transportation and communication infrastructure.

Under the above conditions, the urbanization of the Yangtze River Delta development zones themselves is characterized by the following features: rapid economic growth and urban spatial expansion; industrial-led urban development with relatively poor social functions and uneven urban functions; mutual promotion and synergistic development of the development zones and the overall urbanization process of the cities in which they are located; and large-scale infrastructure construction and strong administrative support, Under the premise of large-scale infrastructure construction and strong administrative support, urbanization with the development zone as the core has a huge driving effect on the surrounding rural areas.

The establishment of development zones and the phenomenon of urbanization have led to changes in the urban spatial pattern of the Yangtze River Delta. In Suzhou, for example, between 1992 and 2000, two national-level development zones and five provincial-level development zones were established around the main city of Suzhou. The development zones have gradually developed into new urban areas and have been spatially extended and expanded to become integrated with the main urban area (Figure.6).

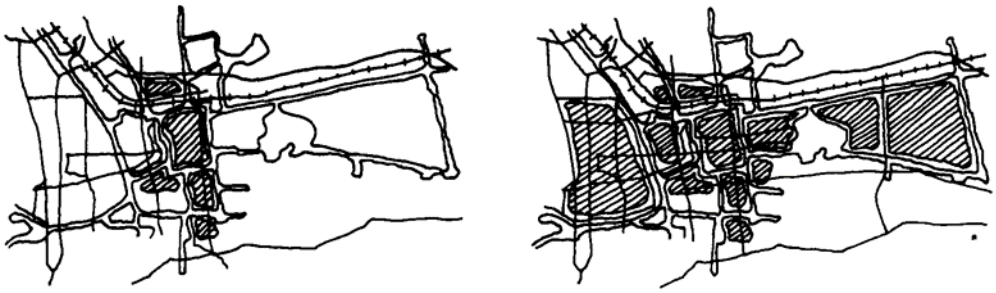

Figure 6 – Suzhou Urban Space 1992-2000
Source: Suzhou Urban Design Institute

Although only the State Council and inter-provincial governments can establish development zones, a "development zone fever" began in 1988 throughout the country. By the end of 2003, there were 6,015 development zones of all kinds in China, more than two-thirds of which were approved by governments below the provincial level, and the planned area of all kinds of development zones nationwide was more than one times higher than the built-up areas of cities (Table.1). The taxation system, fiscal system, urban construction and maintenance fund raising system, administrative division and management system, and other systems in place at the time were conducive to the development of development zones. As a result, many development zones were blindly established by local governments in pursuit of urban economic development (Hong, 2004).

"Some localities and departments have approved the establishment of various types of development zones (including parks and resorts, the same below) under a wide variety of names without authorization, arbitrarily encircled a large amount of arable land and illegally granted and transferred land, and overstepped their authority to introduce preferential policies, resulting in an excessive number of development zones that clearly exceed the actual needs and seriously damage the interests of farmers and the state." （At the end of 2003, the State Council issued the *"Notice on the Suspension of Approval of Various Development Zones"* and China began a three-year "Clean-up of Development Zones". At the end of 2003, the State Council issued the *"Notice on Suspension of Approval of Various*

Development Zones", and China began a three-year "clean-up and consolidation of development zones".

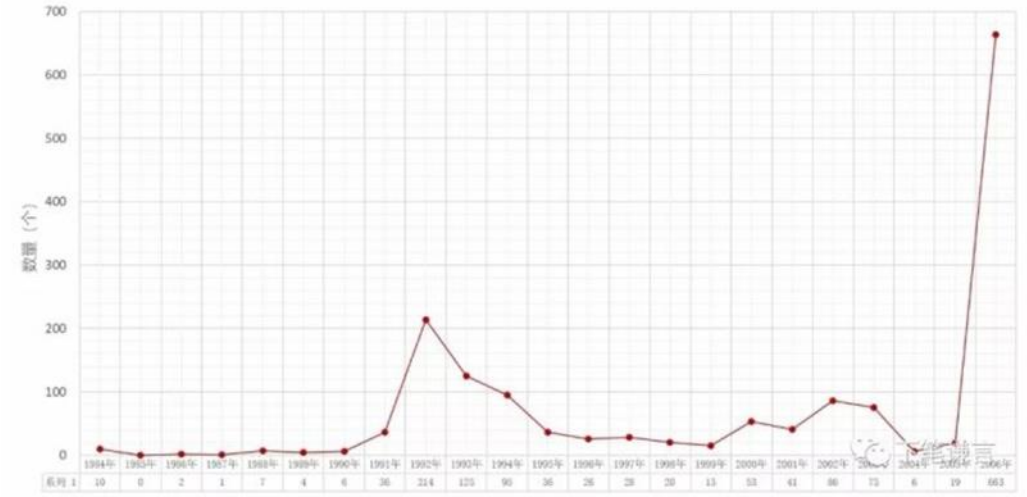

Table 1 – Number of construction development zones in China over the years, 1984-2003
Source: China Development Zone Website

In all, after the founding of New China, although China's urbanization was in the doldrums during the planned economy, it has rapidly increased after the reform and opening up with a series of policies in political, economic and social aspects. The main policies include the introduction of market economy, decentralization (reform of land system, housing system, and taxation system), opening of household registration system, construction of new cities and new urbanization strategies. On the other hand, China's urbanization has shown regional differences due to the policies and implementation methods introduced by local governments at all levels. Local governments usually promote urbanization in their respective jurisdictions through administrative zoning, institutional innovations (administrative system, land system, household registration system, etc.), policy preferences, and the establishment of development zones. These evolving policies are designed to promote urbanization in China and actively address the problems of China's

urbanization process. China's urbanization reflects a mixture of market mechanisms and state policy guidance (Wu, 2020).

1.2 Characters of the Chinese urban transformation

The most characteristic feature of China's urban transformation is the planning-centered urban expansion, and the market is only a tool to assist and reinforce the planning. In this context, China's urban expansion has been very rapid, and its most prominent manifestation is the development of a large number of new towns. Faced with the dilemma of rural development in the midst of urbanization, China's urban transformation presents a complex mix of urban-rural dichotomy and integration. In addition, even under the strict urban governance policies of the state, urban migration has created an informality in the urbanization process, resulting in a ponderable urban landscape.

1.2.1 Planning-centered urban expansion

China is unique in the world in that the government has always played a leading role in China's urbanization process. To promote urbanization, the central government sets the macro system, growth model and policy framework, and local governments define and implement the policy details within their jurisdictions according to the framework. From the beginning, China's urbanization has been characterized by a planning-centered development. Even in the post-reform and opening-up era, when market-regulated behavior has become more pronounced, the government still firmly holds the reins of urban governance through planning.

In some western countries with developed market economies, with the deepening of urbanization, the former government-oriented "urban managerialism" is giving way to the so-called "urban entrepreneurialism" (Harvey, 1989). The government has abandoned its long-standing welfarist principles and has given priority to relying on market mechanisms, promoting economic growth, improving urban competitiveness, and attracting

foreign investment. In China's current urban governance, local governments have more autonomy due to decentralization, and real estate development has introduced active market participation in the urbanization process. However, a transposed urban corporatism view of China's urban development ignores the country's particular political system. Wu (2018) argues that "state entrepreneurialism" can more accurately explain the Chinese government's approach to managing cities: keeping planning central and making the most of market regulation.

Since the reform of the land and housing systems, local governments have been given the right to transfer land for a fee, and they have indeed reaped high revenues from massive land concessions and real estate development. However, it is too one-sided to attribute this behavior to the pursuit of urban GDP growth and job promotion (Li & Zhou, 2005). The behavior of local governments is not limited to short-term interests, but involves longer-term industrial upgrading and promoting urban development, and more importantly, maintaining consistency with central government policies (Wu, 2018). In general, local governments consolidate the power and prestige of the central government through a certain degree of market behavior to meet the urban development goals set by the state. The central government gives local governments a certain degree of freedom through decentralization and policy preferences, while maintaining the absolute authority of the central government itself by appointing lower-level government officials to restrain localities.

The "Sanjiu Transformation" project in Guangdong Province is a good example of state entrepreneurialism. "A typical example of this is the 2007 Dachong urban village renovation project in Shenzhen. Dachong is currently the largest urban village renovation project in Guangdong Province. The project covers an area of 685,000 square meters and involves the relocation of nearly 1,000 original villagers, more than 300 non-villagers, the relocation of about 70,000 residents and the demolition of more than 1,500 houses (nearly 1.1 million square meters). Dachong Village is located in the urban landscape zone along Shennan Avenue and adjacent to the Science and Technology Park. The village is densely

populated with buildings, narrow and disorganized streets, and dimly lit interiors, in stark contrast to the modern and clean urban landscape around it. The villagers' "handshake buildings" have certain fire hazards and a lack of public facilities, making them a difficult social problem at the grassroots level.

In the end, Dachong adopted a combination of demolition and reconstruction and partial comprehensive renovation model. In the process of implementation, the operation mode of "government-led, market-oriented operation, joint-stock company participation" was adopted. Through an in-depth study of the current situation, the interests of all parties concerned were taken into account. The combination of old village renovation and market economy ensures a reasonable profit for the renovation and development, which effectively drives the enthusiasm of the renovation implementation bodies and promotes the renovation of old village areas faster. The local government sends a resident working group to Dachong Village to guide and coordinate the work of the two cooperating parties. Among the three parties: villagers, government and enterprises, "villagers benefit" is the first priority, they can get monetary compensation and property compensation. The transformation of Dachong is carried out smoothly with the support of the tripartite team of government, enterprise and village and mainstream public opinion. Although the "Sanjiu Transformation" projects such as Dachong involved multiple participants from villagers, government, and enterprises, the government maintained a key role as the project leader and negotiating platform provider, reflecting the central position of planning in China's urban transformation governance.

So for urban governance in China, it is not the urban that has an entrepreneurial nature, but the state that has an entrepreneurial nature. With the permission of the state, local governments can make full use of the market, invite multiple stakeholders to negotiate and solve problems, and ultimately promote the optimization of urban areas, but this set of actions is constrained within the framework of top-down planning.

1.2.2 Rapid urban expansion and the development of new towns

In 1980, China's urbanization rate was only 19.39%, far behind the world average; in 1990, China's urbanization rate reached 26.44%, in 2010 it reached 49.95%, and in 2020 it will reach 63.89%. The rapid growth of the figures in the four decades reflects another characteristic of China's urbanization - the rapid expansion of cities.

Based on the previous analysis, it is clear that in order to seek to span the scale of urban space, local governments will directly increase urban area through administrative zoning adjustments. At the same time, some local government officials, perhaps due to GDP competition, career considerations, or to meet the policy considerations of the central government, will strive to obtain land use targets from their superiors. The behavior of these officials has to some extent caused rapid expansion of urban land. In addition, with the development of the city, the land price in the main urban area rises. Out of speculative effect, many manufacturing industries were likely to purchase commercial land at this time, and many companies spent a significant portion of their investment on land hoarding. Soon after, the central government introduced stricter land management. Currently, China's urban construction land has been under the planning framework of the Ministry of Housing and Construction and the Ministry of Land and Resources, and the current planning standard is that for every 10,000 new residents, you get 1 square kilometer of construction land. Given urban construction planning and land use targets from the central to provincial governments, local governments have to think of various ways to make the expected population size larger, such as building various new towns, in order to get more construction land targets (Zhou, 2017).

The term "new town" can include new towns, new regions, new districts, new cities, and other spaces that are newer than the current urban space (Chen, 2010). New towns themselves are very ambiguous (Governa & Sampieri, 2020), their function, structure, and relationship with the main city are often different and difficult to categorize or define. At the

same time, the existence of new towns seems to blur the boundaries between urban and rural, between center and periphery.

New towns have been described as chaotic urban/non-urban spaces (Governa & Sampieri, 2020), occupying urban boundaries in a piecemeal manner and spreading outwards, which also includes university towns, technology town, port new town, etc.

Take a university town for example. Currently there are 56 university towns established in China. There are several reasons for the creation of university cities; for universities, urban development has led to a deterioration of the learning environment as school locations change from suburban to urban centers (Liu, 2013); large-scale university mergers have necessitated the consolidation of scattered campuses to create new campuses; and the rapid expansion of university enrollment has brought about an increased demand for educational facilities. For local governments, some regions with less developed higher education hope to promote the development of higher education and even science and technology through university towns; suburban areas are unattractive and scattered due to urban expansion, and local governments hope to increase the attractiveness of suburban areas by promoting the establishment of supporting infrastructure and service provision through the establishment of university towns (Wu, 2018); in addition to this, educational land is not subject to the 2004 the mandatory land auction system that started to be implemented, and local governments can transfer suburban land to schools at a lower price. University towns are developed as green spaces with beautiful landscape effects.

As far as most university towns have been built, the large scale of university town sites has led to a crude rather than intensive use of land. The excessive campus size and facilities far away from each other, beyond the customary walking range, create problems for the study and work life of faculty, staff and students. The lack of infrastructure around a university town fails to attract crowds, lacks urban life, and even becomes an island far from the main city. Essentially, a university town is a large urban project similar to a transportation hub (Jiang et al., 2016).

Take Nanjing Xianlin University Town as an example, it is one of the first university towns established in China, 15 km from Xinjiekou in the city center. By the end of 2013, Xianlin University City has 12 universities, 6 primary and secondary schools and nearly 20 kindergartens in residence, and the planning area has concentrated about 8% of the university students enrolled in Jiangsu Province, accounting for about 15% of the total higher education resources in Jiangsu Province, making it an important higher education agglomeration in Jiangsu and China. However, Xianlin University City has many of the common problems of a university city: it has a very large site size of 47 square kilometers, and the schools are scattered and usually require subways or buses to reach each other. Not only is the area of the university city large, but the area of the university campuses it contains is also very large. The Xianlin campus of Nanjing University has a planned area of 4,910 mu, and faculty, staff and students often need shuttle buses and bicycles to help with commuting. In addition, the rigid campus planning lacks the humanistic atmosphere of Nanjing University itself, and the campus loses its fun and living atmosphere. As for the infrastructure around the university town, although the subway was established long ago, some cultural and entertainment implementations have only slowly emerged in the last decade, lacking an urban living atmosphere (Figure7-8).

New towns such as university towns are the product of a combination of planned centrality and market instruments under Chinese state corporatism, and they embody residential suburbanization and post-suburban development (Li et al., 2014), which also exacerbate the rapid expansion of urban areas. Although these new towns themselves were established out of a desire to agglomerate education, technology, and industry, they were used in a decentralized, multiform way to occupy space at the urban-rural interface in response to the government's quest for perfect urbanization data and lax regulation of suburban land. Although these lands were eventually expanded rapidly into urban sites, they failed to perform good urban functions and resulted in wasted land.

Figure 7-8 – Upper: Nanjing University Xianlin Campus (University town) Lower: Nanjing University Gulou Campus (Downtown)
Source:https://baike.baidu.com/item/%E5%8D%97%E4%BA%AC%E5%A4%A7%E5%AD%A6%E4%BB%99%E6%9E%97%E6%A0%A1%E5%8C%BA

1.2.3 Urban–rural dualism and urban-rural integration

The relationship between urban and rural areas in China's spatial development presents an ambiguous state of antagonism and unity.

From the early days of the founding of the country to the pre-reform period, China developed an urban-rural division in the context of the household registration system and the planned economy. During this period, China adopted a development model that prioritized industry at the expense of agriculture, unconventional means of controlling the countryside, and an urban-biased construction input mechanism (Zhang, 2019), which led

to great damage to farmers' productive lives and rural development. After the reform and opening up, the urban-rural dualistic economic system was gradually broken through empowering farmers and promoting market-oriented reforms, and the household contract responsibility system weakened government control over rural economic activities and strengthened the autonomy of rural communities and farmers (Dong et al., 2021).

The "New Socialist Countryside" policy of 2005 kicked off the transformation of China's rural areas. With the development of industrialization and urbanization, agriculture is given a basis for sustainable development through the feedbacks from cities to rural areas and from industry to agriculture, so that rural society can achieve harmony. The government makes up for the infrastructure construction of the countryside and improves the landscape environment of the countryside through massive financial investment. On the other hand, Wu (2018) argues that through a series of measures, the corporatist nature of state land planning allowed the government to extend its power to the largely "unplanned" rural areas, strengthening state control over the countryside.

In 2006, the government completely abolished the agricultural tax, which on the one hand significantly reduced the burden on farmers and on the other hand led to a decline in rural public finance capacity, putting the countryside at greater risk in times of economic crisis, and in 2008, the central government enacted the Urban and Rural Planning Law, which mandated that built-up areas of cities, towns, and villages, as well as areas needed for urban and rural construction and development, must be built under strict planning control. Rural areas, which were originally more freely developed and mainly privately governed, were at this time brought under government control. Lin (2014) argues that this planning law only facilitates the government's use of rural land while protecting "basic agricultural land" and providing sufficient space for urban construction. Most of these rural lands have become potential sites for urban construction, further providing institutional protection for China's urban sprawl and, to some extent, strengthening the exploitation of rural resources by cities. Despite the banner of integrated urban-rural construction, these policies continue the design thinking of the urban-rural dichotomy.

In terms of urban-rural mobility, the government in this period still required urban and rural residents to enjoy the basic public services available to each within a clear boundary according to their household registration status. In addition to public service names being given the distinction between urban and rural areas, the service standards, operational procedures, and funding methods are significantly different, and there is still a clear gap between urban and rural areas (Zhang, 2019).

In terms of spatial governance, the supply capacity of public services in China is mainly concentrated in urban areas, and rural areas have been lacking in governance capacity (Wu. 2018). Jiangsu was one of the first places to start rural governance. Jiangsu Province is both one of the pioneering regions in China's economic and social development and a province with more affluent traditional villages that have experienced the rapid development of township industries, with a relatively small urban-rural gap, but the gap between urban and rural habitat and infrastructure levels is still large (Gan, 2017). With the support of the provincial government, the Department of Construction launched a rural construction program in 2012. The aim was to manage the natural environment of villages, deal with public health, waterway maintenance, waste recycling and transfer, as well as landscape beautification and preservation of ancient villages. But even in the affluent Jiangsu region, rural problems are piling up and the early years have not been very effective. The infrastructure in the vast rural areas is still weak, the phenomenon of dirty and disorderly living environment is still prominent, and the exploitation and consumption of agricultural resources are superbly excessive. Agriculture and even rural economic and social development are facing severe challenges such as tightening resource constraints, serious ecological degradation and increasing environmental pollution (Guan, 2014).

In 2013, at the Fifth Plenary Session of the 16th CPC Central Committee, the central government proposed to build The beautiful countryside. Xi Jinping especially emphasized that building a beautiful countryside is to benefit the villagers and not to waste money on superficial projects, such as painting the outside of the house with a layer of white ash, a white covering a hundred ugly. The old villages in particular should be protected.

In the context of the policy of the beautiful countryside, the Jiangsu provincial government realized that simple rural construction could not generate profits, and to ensure the sustainability of rural governance, a form of governance with market participation was adopted, but it is worth noting that this governance is still centered on government planning. The government provides appropriate funding for pilot projects and invites planning institutions and universities to participate in the planning, while ensuring that farmers are the protagonists of the project and that the planning fully respects the wishes of farm names (Wu, 2018). The so-called market participation means introducing rural tourism and encouraging farmers to invest in their productive living space. Although pointing to tourism development, the planning ensures the preservation of the rural terroir and highlights the rural regional characteristics. From 2017 to 2021, the construction of characteristic rural villages in Jiangsu Province has moved from the pilot demonstration stage to the pilot deepening and surface creation stage. At present, the province has built 324 provincial characteristic rural villages, covering 93.4% of the counties (cities and districts) involved in agriculture. From the creation of the point to the regional construction, showing a vibrant model of a beautiful countryside, showing a vivid picture of the countryside and the bustling city, forming an influential "brand effect" in the country.

Jiangsu's approach to rural governance begins with improving the physical foundation of the countryside, and continues with the introduction of rural tourism to create funds for ongoing construction. To some extent, such rural construction has contributed to the economic development of the countryside and reduced the gap between urban and rural development. Rural tourism even inspires urban residents to pay attention to the countryside; according to a 2020 poll in Jiangsu Province, driving to the countryside on weekends has become one of the common recreation options for urban residents in Jiangsu (Jinling Evening Newsthesis, 2021) (Figure.9).

Figure 9 – Beautiful Countryside Governance in Jiangsu Province
Source:https://www.bing.com/images/search?q=%e6%b1%9f%e8%8b%8f%e7%9c%81%e4%b9%a1%e6%9d%91%e6%97%85%e6%b8%b8&form=HDRSC2&first=1&tsc=ImageHoverTitle

1.2.4 Active people and informality

The household registration system has undergone years of reform, but it still poses a great obstacle to the mobility of urban and rural residents, and the urban-rural dichotomy still exists in China's urban transformation. Along with the urbanization process, the lives of both mobile and local residents are significantly affected (Liu et al., 2018). Because of various reasons such as household registration, housing, income, and accent, migrants are likely to be discriminated against, and social discrimination gradually arises in urban life. But neither the native people nor the immigrants are contrary and they show initiative in shaping and changing their living environment (Lefebvre, 1991). The adaptation or resistance to urbanization by various groups of people also contributes to the informality of the urbanization process in China.

For high-income urban natives, the arrival of foreigners means that there is competition for urban resources between the two, and some profitability. These high-income indigenous people will seize the opportunity to upgrade their properties and spend money to improve their living environment, thereby attracting new tenants (Zhan, 2018). These new tenants tend to be younger, well educated, and wealthier (Arkaraprasertkul, 2018), and they crowd out low-income indigenous households, ultimately creating a gentrification of urban space. So even the urban natives, especially the low-income people

living in the old city, suffer the most from this gentrification process and can even be discriminated against. A study of gentrification in Nanjing showed that passively relocated low-income indigenous people are discriminated against when seeking employment in the job market (Xia, 2014).

In the radical urbanization process, for the rural aborigines, there exists a part of people who have lost their homes due to the massive expropriation of rural land. Some people are not satisfied with moving to government-arranged resettlement houses and still insist on maintaining their original dwellings. With urban construction, their original homes become urban villages. The urban village is a typical informal example of urbanization in China and a testament to the dichotomy between urban and rural areas (Figure.10). Urban villages have a harsh environment, but because of the low rents, they are home to not only rural aborigines who do not want to move, but also low-income immigrants. Over time, these people have informally taken control of this part of the urban space and reconfigured the urban landscape. Their initiative bridges the gap that exists between their own needs and those allowed by the formal system (Logan, 2018).

Figure 10 – Urban Villages in Guangdong Province
Source: https://zhuanlan.zhihu.com/p/28669581

The phenomenon of urban villages embodies the planning-centered urban transformation of China does not mean that informality can be eliminated (Wu, 2018). Nor

can informality be eliminated. While the state can govern the city, it cannot fully control the development of the city. It is a very arrogant approach to consider the urban village as a persistent problem of the city. The government is limited by funding, coordination ability, and ultimately has to choose to compromise with informality.

The flow of rural population to cities and the flow of population from small cities to big cities is one of the most essential phenomena of urbanization. Take Shanghai as an example, according to 2017 data, Shanghai's foreign population accounts for 40.51% of the population, the highest number of foreigners among several first-tier cities in China. Due to disparities in household registration, income levels, education levels, and accents, immigrants face many difficulties in living and working in their new cities. They are discriminated against and even marginalized in employment, social activities, political participation, and home ownership. But instead of giving up on themselves, immigrants try to use their agency to adapt or improve their survival (Logan, 2018).

It is more common that immigrants will actively participate in various social activities and try to integrate into the life of their new neighborhoods. The new neighborhoods formed can bring some emotional support to migrants, enhancing their attachment to their new neighborhoods and their willingness to stay in the city. (He & Qian, 2017). In addition to this, it is the formation of immigrant gatherings by living in groups according to their origin and ethnicity. These immigrants overcome cultural, geographical and other limitations to create their own urban space. In Guangzhou, there is a place called "Little Hubei", where immigrants from Tianmen, Hubei are engaged in textile manufacturing and commerce (Liu, 2015). In many cities in China, there are also settlements of Muslim immigrants, usually in a certain area or street, but they gather mainly to maintain their religious beliefs and customs.

Chapter 2 Chinese new town

It is clear from Chapter 1 that new towns are a product of China's distinctive urbanization process. Therefore, the legislation, role and challenges of new cities are what this chapter wants to discuss in depth.

The study and development of new towns in China is relatively recent, dating back to the "Liang-Chen Scheme" proposed by Liang Sicheng and Chen Zhanxiang in the 1950s. The Liang-Chen proposal advocated the use of organic evacuation theory to guide Beijing's urban construction through the construction of a new district to avoid large-scale demolition and relocation, and to continue the cultural landscape pattern of Beijing. On the other hand, the Liang-Chen proposal emphasized the segregation of green belts in clusters, the balance of jobs and housing, and the reduction of cross-regional traffic. However, the "Liang-Chen proposal" was not adopted in the end, and the study of new towns in China entered a period of silence until 1978, when the reform and opening up were followed by the development practices of special economic zones and economic development zones.

There is no unified standard for the definition of new towns in Chinese academia. According to the characteristics of foreign new towns and the specific national conditions of China, the group of the Institute of Geographical Sciences and Resources of the Chinese Academy of Sciences proposed two concepts of new towns in the broad sense and the chivalric sense in 2014. New town in the broad sense refers to new city centers established in former rural areas in China's provinces and cities since 1979 (the establishment of Shekou Industrial Zone) with relatively independent administrative institutions and one or more functions (such as industry, commerce, residence, community public services and culture and entertainment). A new town in the narrow sense refers to a comprehensive urban center with relative administrative, economic, social and cultural independence and greater autonomy established by cities in China since 1992 (when the Pudong New Area was established) at the edge of or outside the former central urban area. The narrow definition

does not include industrial parks, university parks, science and technology parks and other "single-function" "new urbanization segments", but rather new towns with more mature integrated urban service functions.

In order to comprehensively clarify and analyze the legislation, role and development of new towns, this thesis adopted a broad definition of new towns for the study. Based on such definition, the new towns discussed in this thesis can be divided into three types:

1. national new districts led and approved by the State Council;
2. development zones approved and established by the State Council or provincial people's governments;
3. functional new towns led by local people's governments (including industrial parks, industrial concentration zones, science and education new towns, new governmental affairs districts, Olympic sports new towns, high-speed railway new towns, port new towns, airport new towns, intelligent new towns, (including industrial park, science and education new city, new governmental district, Olympic sports new city, high-speed railway new city, new airport new city, smart new city, eco-low carbon new city, future science city, etc.).

At the end of this chapter, in view of the advantages and dilemmas of the current new town development, this thesis explored the ways to expand the positive role of new towns through underground space development, and the possibilities to solve or alleviate the disadvantages of new towns.

2.1 Legislation of the Chinese new town

Based on the development and policy evolution of new towns in China, the legislative process of new towns can be roughly divided into three stages: The initial exploration stage of new town legislation from 1979 to1988; The differentiation stage of

local new town legislation from1988 to 2006; and since 2006, the breakthrough innovation stage of new town legislation.

2.1.1 1979-1988: The initial exploration stage of new town legislation

The construction of new towns in China originated from the Shekou Industrial Zone in 1979. With the "economic construction as the center" and the major opportunity of reform and opening up made by the Third Plenary Session of the 11th Party Central Committee, China Merchants developed the first export-oriented economic development zone in China. The Shekou Development Zone was a testing ground for the construction of special economic zones in China, taking advantage of its geographic proximity to Hong Kong to consciously explore the transition from being a pioneer of economic system change to a pioneer of social system change.

In July 1979, the CPC Central Committee and the State Council agreed to set up export special zones in Shenzhen, Zhuhai and Shantou in Guangdong Province and Xiamen in Fujian Province on a trial basis. On August 26, 1980, the fifteenth meeting of the Standing Committee of the Fifth National People's Congress approved the promulgation of the *"Regulations on Special Economic Zones in Guangdong Province"*, which was the first law on special economic zones. This law was based on the advanced legislation of Hong Kong, Singapore and other regions. At this time, most of the state policies for SEZs were fixed in the form of laws. For example, the tax preferential policies given by the state to the SEZs and the foreign exchange preferential policies were fixed in the form of legislation (Lin, 2019).

In 1984, the State Council approved 14 new economic and technological development zones in 14 coastal cities, including Dalian. By 1988, the State Council had approved the establishment of a total of 18 economic and technological development zones. The Standing Committee of the People's Congress of the provinces and municipalities directly under the central government where these state-level development zones are located legislated the management system of the zones by means of "regulations on

economic and technological development zones". The local governments, in turn, formulated specific documents to clarify the powers and responsibilities and development goals of the development zones in accordance with the higher-level documents (such as the above-mentioned "Minutes of the Symposium on Selected Coastal Cities") and the regulations of the development zones.

During this period, China's new towns were special economic zones and economic and technological development zones specifically established by the State Council, and provincial and sub-provincial governments had no authority to develop new towns. National laws on the establishment and management of new towns were mainly based on those of the more advanced neighboring countries and regions. The specific "point-to-point" legislation enacted by the State for SEZs and development zones only serves specific new towns and is not universally applicable at the national level or at the provincial level. These laws and regulations are not part of a system of legislation and can only be considered as "special" arrangements (Zhou, 2019).

2.1.2 1988-2006: The differentiation stage of local new town legislation

On July 1, 1992, the Standing Committee of the National People's Congress (NPC) granted legislative power to the Shenzhen Special Economic Zone (SEZ), which was the first sub-provincial city in China to have legislative power, thus entering a new phase of SEZ legislation. In the past two decades, the central government has gradually delegated the legislative power, and each SEZ has gradually improved the speed and quality of legislation. In addition, the 2000 *Legislative Law* regulated the legislation of special zones differently from the delegated authority. As of June 2006, the Shenzhen SEZ alone had adopted a total of 296 regulations and decisions on regulatory issues, covering all aspects of the economy and society. The enactment of regulations in the SEZ still draws mainly from the advanced legislation of Hong Kong and developed countries. Regulations were enacted in all major areas of the SEZ at this stage, providing a strong legal guarantee for the reform and opening

up of the zone, the development of market economy, the establishment of market order and social progress.

In 1988, provincial people's governments were allowed to approve the establishment of provincial development zones, followed by provinces gradually introducing their own regulations on the management of development zones. The liberalization of the approval of the establishment of provincial development zones has resulted in a "development zone frenzy" throughout the country, with many local governments overstepping their authority to approve various development zones. Prior to 2003, the approval system, naming and management of development zones in China were in a state of chaos, and in 2003 the State Council issued the *"Notice on Suspension of Approval of Development Zones"*, which began a three-year process of "clean-up and consolidation of development zones" throughout the country. In 2005, the *"Opinions on Promoting Further Development of State-level Economic and Technological Development Zones"* was published. At the same time, Shandong and Shanghai were the first places in the country to adopt local legislation for development zones. Subsequently, many places across the country have followed in the footsteps of local legislation for development zones. The main features of local legislation include: a single target group; prominent policy preferences; and more attention to enterprises in the development zone than to the operation mechanism of the zone.

The construction of Binhai New Town ("Binhai New District") (2000) was the starting point, and the construction of Zhengdong New Town (2003) was the climax. As a result of the national policy direction to clean up and consolidate development zones, many development zones were transformed into comprehensive new towns (new districts). Legislation for comprehensive new towns gradually emerged during this period. For example, in 2002, the State Council enacted and issued the *"Regulations of Tianjin Binhai New District"*, which defined the status, responsibilities, authority, and interrelationships between the Binhai New District Administrative Committee and the administrative and functional districts in legal form (Lu and Wang, 2016).

The legislation of the new towns in this period appears to be distinctly different. Special economic zones have the legislative power and gradually improve their respective legislation, with a major breakthrough in terms of quantity and quality. However, the regulations for the establishment and management of development zones were confusing, and the national regulations for development zones were not very binding, and each province tried to formulate relevant laws and regulations to manage local development zones. At this time, the integrated new towns were all national level, for which the state made laws and regulations separately, and there was no unified national legislation for integrated new towns.

2.1.3 Since 2006, the breakthrough innovation stage of new town legislation

On July 1, 2006, the Shenzhen Special Economic Zone (SEZ) introduced China's first special law on reform and innovation, *"The Regulations on the Promotion of Reform and Innovation in the Shenzhen SEZ"*, which officially came into force, marking another era of innovation in China's SEZs. With the adoption of the new tax law by the National People's Congress in 2007, the last economic preferential policy of the SEZ, the special enterprise income tax concession, came to an end, making the legislative power of the SEZ the only policy advantage of the SEZ (Tan, 2013). At present, the legislation of SEZs faces the "constraints" of the existing constitution, which makes it difficult to fully mobilize and give full play to the enthusiasm of SEZ legislation. Even though the mission of the legislative power of SEZs is to reform and innovate, there is a need to further improve the relevant top-level system.

After the end of 2006, the State announced "The Interim Measures for the Management of National High-tech Industrial Development Zones" in 2007; *"The Opinions on Promoting the Transformation, Upgrading and Innovative Development of State-level Economic and Technological Development Zones"* in 2014; and *"The Opinions of the General Office of the State Council on Promoting the Reform and Innovative Development of*

Development Zones" in 2017, among several other sectoral The State Council General Office on Promoting the Reform and Innovative Development of Development Zones However, these few departmental regulations are not only of low legal status, but as "opinions" and "provisional measures", they do not empower the development of development zones and their requirements are not binding. To date, China has not developed a national legal system for development zones, and the development of local development zones continues to rely on local people's congresses (provinces, autonomous regions, and municipalities directly under the central government) to provide a legal basis through local legislative processes (Zhou, 2019). Eleven provinces have completed the local legislative process, but only five provinces have formally implemented local regulations on development zones. Although numerous localities have included development zone legislation in their legislative plans, local regulations on development zones are often difficult to come to fruition and remain under constant consultation, with some not even able to get a draft for consultation after several years of brewing.

For several provinces that have implemented their own local development zone regulations, the content of their development zone regulations has been upgraded from focusing on the development of enterprises in the development zone to focusing on the operation and management system in the development zone, and the scope covers all types of development zones. These local development zone regulations have a high degree of commonality and will be the direction for future development of development zones. These include: 1. clear legal status and statutory powers of the management committee; 2. differentiated development of development zones is a requirement and the elimination of winners and losers is the norm; and 3. market-oriented operation of development zones and encouragement of the "management committee + company" system (Zhou, 2019). Although there is still little progress in development zone legislation at the national level, individual local governments have made a breakthrough. These pioneering local regulations have laid the groundwork for development zone legislation in other provinces and cities, and even in the central government (Figure.11).

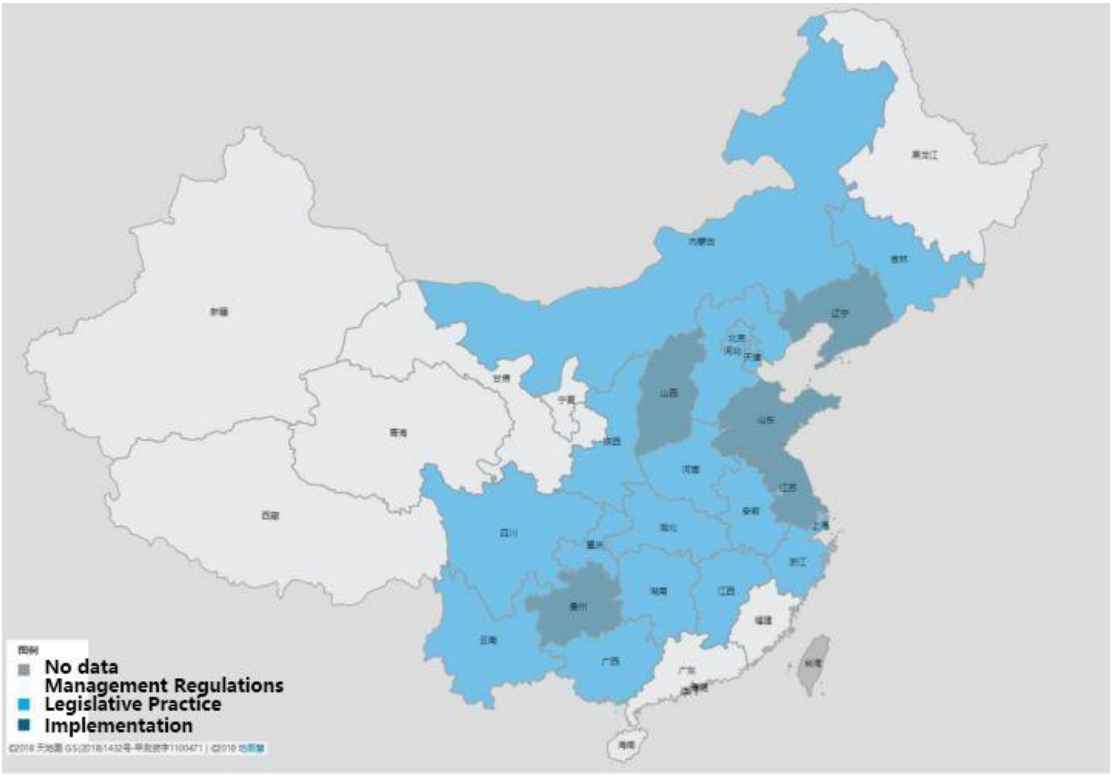

Figure 11 - Process of local regulations for development zones in force across China
Source: https://zhuanlan.zhihu.com/p/63398292

During this period, comprehensive new towns (new districts) at the national level flourished, and comprehensive new towns (new districts) at the provincial and municipal levels were gradually established.

On January 1, 2008, *"The Urban and Rural Planning Law of the People's Republic of China"* (hereinafter referred to as the "Urban and Rural Planning Law") came into force, and the Urban Planning Law of the People's Republic of China was repealed. *The Urban and Rural Planning Law* clearly stipulates that "the relationship between the development of new towns and the reconstruction of old towns shall be properly handled" and that "the development and construction of new towns shall reasonably determine the scale and timing of construction, make full use of existing municipal infrastructure and public service facilities, strictly protect natural resources and ecological environment, and reflect local Characteristic. In the city master plan, the town master plan to determine the scope of

construction land outside, not to set up all kinds of development zones and new urban areas."

With the decentralization of the central government in recent years, provinces and cities have also formulated new town regulations to protect the development and construction of comprehensive new towns (new districts) at the national, provincial and municipal levels within their jurisdictions, but most are still legal regulations for single new towns. For example, the 2011 *"Zhuhai Special Economic Zone Hengqin New Area Ordinance"* and the 2021 *"Hebei Xiong'an New Area Ordinance"* of Hebei Province provide comprehensive and systematic regulation of the planning and construction of a single new area at the legislative level. On February 23, 2021, the Shanghai Municipal People's Government issued the *"Implementation Opinions on Accelerating the Planning and Construction of New Cities in the 14th Five-Year Plan"* (hereinafter referred to as *"Implementation Opinions"*), which sets out the general requirements and implementation strategies for the construction of new cities in Shanghai, and designs A series of new town construction implementation guarantees and initiatives. The *Implementation Opinions* lead Shanghai's current five new towns construction plans through the construction of the rule of law for major decisions.

Since 2006, the legislation of the Special Economic Zones (SEZs) has been in the testing ground of reform and innovation, and the contradiction between the laws of the zones and the national constitution has gradually deepened. The legislation of the SEZs tries to seek a breakthrough of reform by improving the upper-level laws. There is a situation that the national level of development zone legislation lags behind the local level, and the advanced regions drive the backward regions. It has become a trend for advanced local development zone legislation to drive national development zone legislation from the bottom up. For comprehensive new town legislation, the national level and most local levels are still stuck in single new town legislation, and most of its contents are not universal and generalizable. However, Shanghai has a breakthrough approach in legislating the macro development of multiple new towns within its jurisdiction, leading the way to standardize

the construction of five new towns through the rule of law. Shanghai's new town legislation has a pilot and leading role for the macro legislation of new towns in China.

2.2 The role of the Chinese new town

New town construction is a successful model for cities in the past hundred years to divert the population and industries in the main urban areas, prevent the spread of urban pie and solve urban diseases. According to incomplete statistics, before the 1990s, developed countries in Europe and the United States had built more than 280 new towns with various characteristics, which have made very important contributions to the urban transformation of these countries and the resolution of various urban crises. Therefore, since the beginning of reform and opening up, new towns have been built as a carrier of many development strategies and institutional innovations in China.

The special economic zones and economic and technological development zones established in the eastern coastal areas became the pioneer zones for China to attract foreign investment, expand exports and promote economic growth. The subsequent establishment of state-level development zones has effectively enhanced the development of China's high-tech industries and its participation in economic globalization. With China's national strategies to promote coordinated regional development, such as the development of western China, the revitalization of northeast China and the rise of central China, the number and proportion of various national development zones in the central and western regions also increased significantly during this period. Especially since the 21st century, China has witnessed a boom in the planning and development of new cities in the midst of rapid urbanization. With the advantages of "large volume" and "fast speed," new towns provide sufficient space to support a large number of new urban populations in a short period of time (Wang, 2017). At the same time, new towns are early demonstration areas for institutional reform and urban governance system innovation in China. New towns have made a lot of exploration in streamlining and optimizing the administrative approval

process, innovating the urban land management system, and supporting the development of industrial innovation, which provide urban governance experiences for China's cities to develop more efficiently.

Overall, the construction of new towns in China has solved the residential and employment problems of a large number of people, made the spatial structure of cities more reasonable, made the urban living environment significantly improved, enhanced the quality of urban development and urban competitiveness, and driven the healthy and sustainable economic and social development of cities and regions.

2.2.1 Attracting people to live and work

The construction of new towns attracts a large number of people to live and work. According to the seventh census, in 2020, Chongqing Liangjiang New Area has gathered 3.4 million people to live and work there, and more than 10% of Chongqing's population is gathered in Liangjiang New Area; Shanghai Pudong New Area has gathered 5.682 million people to live and work, accounting for 22.8% of Shanghai's total population, making it the most populous district in Shanghai; Tianjin Binhai New Area has gathered 2.067 million people to live and work, accounting for 19.9% of the city's Tianjin Binhai New Area has 2.067 million people living and working in it, accounting for 19.9% of the city's total population. The population absorbed by the new towns mainly consists of three types: 1. attracting the local population living in the new towns to urbanize locally and take up local employment nearby to prevent being attracted to the metropolitan downtown area; 2. evacuating the existing overpopulation in the old urban centers to come to the new towns for employment and residence; and 3. attracting the new foreign employment population (referring to the population from outside the province) to come to the new towns to live nearby in order to disperse the gathering of foreign employment towards the old urban areas (Zhu, 2018).

The absorption of a large number of people by new towns can be divided into three main stages: the new town receives spillover industries from the mother city or has its own

new industries at the beginning of its establishment. Industries, especially labor-intensive industries, will meet the employment of part of the population in the mother city when they develop, while providing jobs for a large number of migrant workers. However, at this time, the residential areas and infrastructures in the new towns are not yet perfect, and the labor force travels between the new towns and the mother city. After a period of time, as the industries in the new towns continue to develop and the supporting residential facilities and public service systems become complete, the labor force can choose to live in the new towns. Eventually, the new towns will develop into more mature urban spaces with a variety of urban functions, which will attract a more diversified population to live and work in the new towns.

The good living environment and lower housing costs in new towns also encourage some people to move here. Compared to old towns, many new town plans incorporate many domestic and international urban development experiences, especially the theory of ecological development has received unprecedented attention (Zhao et al., 2015). Some new towns with advanced concepts such as "eco-city" and "sponge city" have achieved remarkable environmental construction. High-quality buildings and good ecological landscape have effectively improved the living environment. In addition, new towns are built on the outskirts of the city, and the housing prices are much lower than those in the main urban areas, so many migrant workers choose to settle down in the new towns.

2.2.2 Promote urban economic development and industrial upgrading

Since the reform and opening up, new towns have gradually become the main carrier of local economic construction and urban expansion in China. They also have had an important impact on the national economy. For example, national-level new towns such as Shanghai Pudong New Area, Tianjin Binhai New Area and Nanjing Jiangbei New Area are national strategic emerging industries, high-tech industries, advanced manufacturing and modern service concentration areas, independent innovation demonstration zones and free

trade experimental zones. These national-level new towns have become new power points for national and urban economic development and have made important contributions to promoting national economic development and urban economic transformation. Shanghai Pudong New Area's GDP in 2020 accounts for 33.6% of the city's total economic volume, growing 2.6% faster than the city, and total imports and exports account for 56.6% of the city's total, growing 2.9% faster than the city; Tianjin Binhai New Area's GDP in 2020 accounts for 41.7% of the city's total economic volume, growing 5.0% faster than the city, and total imports and exports account for 69.6% of the city. Nanjing Jiangbei New Area's GDP in 2020 accounts for 14.2% of the city's total economy and grows 5.1% faster than the city.

2.2.2.1 New towns promote urban economic development

In promoting economic development, new cities provide great space for economic growth through institutional innovation, production factor clustering and technological innovation (Jiang, 2020).

Institutional innovation is an important driving force to promote independent innovation and economic development. New towns, especially national-level new towns, need to play the role of promoting and boosting through institutional innovation in order to ensure the smooth and orderly development of the whole city economy. New towns provide the best platform for institutional innovation and a quality environment for practical work (Wu, 2014). For example, national-level new towns have a high degree of autonomy and can introduce new policies that meet their intrinsic development needs under the authority of the central government, and combine multifaceted innovations such as the taxation system, talent system, and science and technology innovation system to promote the development of advantageous industries and strengthen the agglomeration effect of talents, providing a constant source of vitality for the city's economic growth.

New towns enjoy more abundant production factors than ordinary cities and other parts of the city. Adequate production factors are the material basis to ensure the high-speed and high-quality development of new towns. The factors of production mainly include land, labor and capital. New towns use land resources to attract investment, and the implementation of preferential policies allows a large number of enterprises to choose to invest capital and open factories in new towns; local governments' tax revenues increase significantly, and the regional economy gains rapid development, and economic growth in turn increases the value of land, which becomes the basis for the next step of financing and development (Zheng, 2014). The greater the intensive use of land in a new town, the higher the economic benefits per land. Adequate supply of labor factors is the main driver for new towns to promote regional economic improvement. The new towns establish a sound talent introduction system and implement talent incentives with the aim of enhancing the absorption capacity of the labor force. Capital plays an important role in the construction and development of new towns, which promote the supply of capital elements and the rapid development of the real enterprise economy in the jurisdiction by implementing preferential financial policies and improving the financial system (Jiang, 2020) (Table.2).

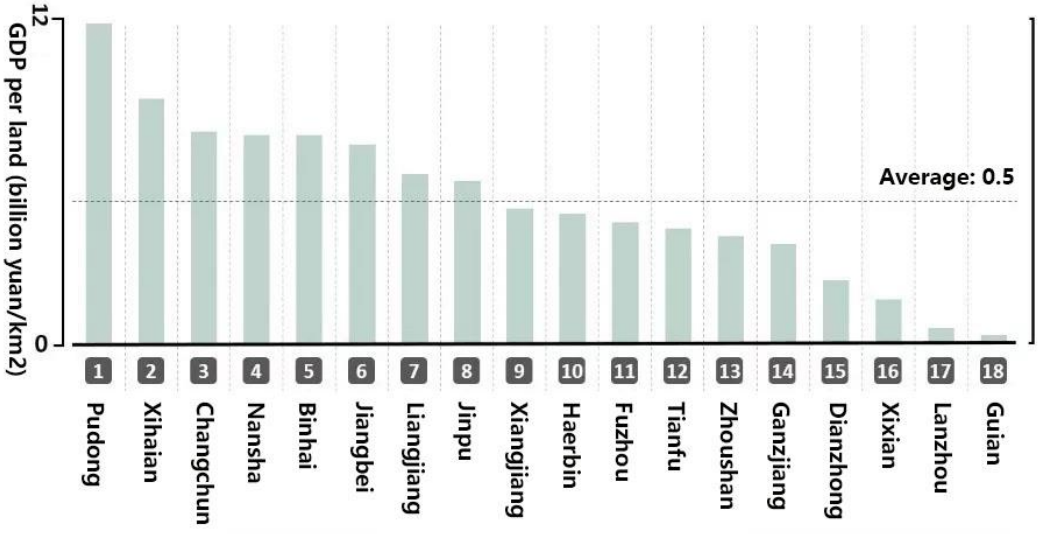

Table 2 - National-level new town average GDP (billion yuan/km2) index

Source: White Thesis on the Planning and Construction Management of New Towns in China

The importance of science and technology innovation for urban development and economic growth is reflected in the fact that many of China's new towns were developed from science and technology industrial parks and high-tech development zones. With the support of central government policies and funding, new towns become key platforms for enterprises, universities and research institutions to collaborate and transform scientific and technological innovations into scientific and technological achievements. Universities and research institutions solve technological innovation problems for enterprises and break through bottlenecks in enterprise development. Enterprises turn scientific and technological achievements into real productivity and apply them to production and practical life, which not only promotes the process of scientific and technological innovation in the new town, but also promotes sustainable economic development of enterprises.

2.2.2.2 New towns promote urban industrial upgrading

The development of new towns also optimizes the functional structure and industrial layout of cities, becomes a "growth pole" for the rapid development of regional economy and society, and improves the quality and efficiency of urban development.

Because of its unique institutional advantages and policy preferences, the new town promotes the agglomeration of financial capital, innovative technology, specialized labor force, high-end high-tech industries and other factors. Such agglomeration advantages create conditions to promote the development of related industries and enterprises (Hu et al., 2021). Led by the national strategy, various new towns have developed a number of strategic emerging industries with informatization, intelligence and greening as the main characteristics according to their own advantages. The industrial structure has been promoted not only in the quantitative transition to the secondary and tertiary industries but

also in the qualitative evolution to high technology, high value-added and high processing, and the optimization of the industrial structure has been achieved. At the same time, under the role of policy-led and market mechanism, production factors can be rationally allocated and flow to the most efficient industries, promoting the coordinated development of various industries, promoting the formation of relatively complete industrial chains and industrial clusters and relatively perfect industrial ecology in the new town, and realizing the rationalization of industrial structure. The transformation and upgrading of industrial structure is the organic unity of advanced industrial structure and rationalization of industrial structure.

Many new towns have been quite effective in leading the industrial upgrading of cities, such as Jiangbei New Area in Nanjing. As a traditional heavy industrial base, Jiangbei New Area has been adjusting its industrial structure. Through innovative cooperation with famous universities and institutes at home and abroad, such as Nanjing University, Chinese Academy of Sciences and Cambridge University, Jiangbei New Area has created a first-class platform for scientific and technological innovation and transformation of achievements. And with the inauguration of financial institutions such as the China-US Financial Technology Laboratory, the new financial center built in Jiangbei New Area is gradually taking shape. Today, Jiangbei New Area focuses on three major industries: integrated circuit, life and health, and new finance. Thanks to the sustainable economic development brought by the optimization of industrial structure, Jiangbei New Area has leaped from a former economic and social development depression to a new important growth pole of Nanjing.

2.2.3 Evacuate urban functions and optimize urban spatial structure

In the context of economic globalization and rapid urbanization, many cities in China, especially mega-cities, have entered a high incidence and high-risk period of urban diseases such as traffic congestion, housing tension and serious pollution exposed in the development process, and are in urgent need of building new towns to alleviate the problems. The

construction of new towns in China has effectively decongested the population and urban functions that cannot be carried by the mother cities, and has taken over some of the production factors that have spilled over from the mother cities. The new cities form complementary industrial linkage and functional linkage with the mother city, realize the transformation and upgrading of the restricted economic structure in the mother city, reduce the overload bearing pressure of the main city, and promote sustainable urban development.

In the process of evacuating functions, the new town further optimizes the structure of urban space. It makes the ecological space of the city more beautiful, the production space more intensive and efficient, and the living space more livable and comfortable. The construction of the new town optimizes the spatial form and structure of the city, improves urban infrastructure and public service facilities, changes the face of urban construction, and enhances the image and reputation of the city.

A typical example is the Xiong'an New Area near Beijing. The planning area of Xiongnu New District involves three counties, Xiong County, Rongcheng, Anxin, and some surrounding areas in Hebei Province, located in the hinterland of Beijing, Tianjin and Baoding. According to the roadmap for planning and construction, the starting area of Xiongnu New Area is about 100 square kilometers, the medium-term development area is about 200 square kilometers, and the long-term control area is about 2,000 square kilometers. According to the Hebei Xiong'an New Area Planning Outline, Xiong'an New Area will be positioned as a centralized bearer for the decommissioning of Beijing's non-capital functions, and will form two new wings of Beijing's development with Beijing's urban sub-center, jointly undertaking the task of solving Beijing's "big city disease". The outline of the plan states that by building the Xiongan New Area, it will adjust and optimize the urban layout and spatial structure of Beijing, Tianjin and Hebei, accelerate the construction of a world-class urban agglomeration in Beijing, Tianjin and Hebei, and explore a new model for the optimal development of densely populated and economic areas (Figure.12).

The Xiongan New Area will create a good urban development environment for the future Beijing by undertaking the non-capital functions of Beijing, industrial upgrading and population transfer (Tian, 2021). After evacuating non-capital functions, Beijing can expand its development space and better perform its core functions as the capital. It will promote Beijing's economic and social development to match the population, resources and environment, enhance the level of development, and realize economic quality and efficiency. The evacuation project is carried out for Beijing's core and central urban areas, mainly including some manufacturing industries, some urban wholesale markets, some educational functions, some medical and health functions and some administrative institutions. Through the deconstruction of non-capital functions and the implementation of the double transfer of related industries and population, it will promote the optimization and upgrading of Beijing's industries and the formation of a highly refined economic structure. Last but not least, by decongesting non-capital functions, the ecological environment of Beijing can be improved and a livable and comfortable city can be built.

The Xiongan New Area was approved for establishment in 2017, and as of 2021, a total of 3,756 Beijing companies have been registered in the transfer of the new area; 90% of the first 26 high-end high-tech companies settled in the Xiongan Citizen Service Center are from Beijing. The decentralization of functions in Xiongan New Area is unfolding step by step.

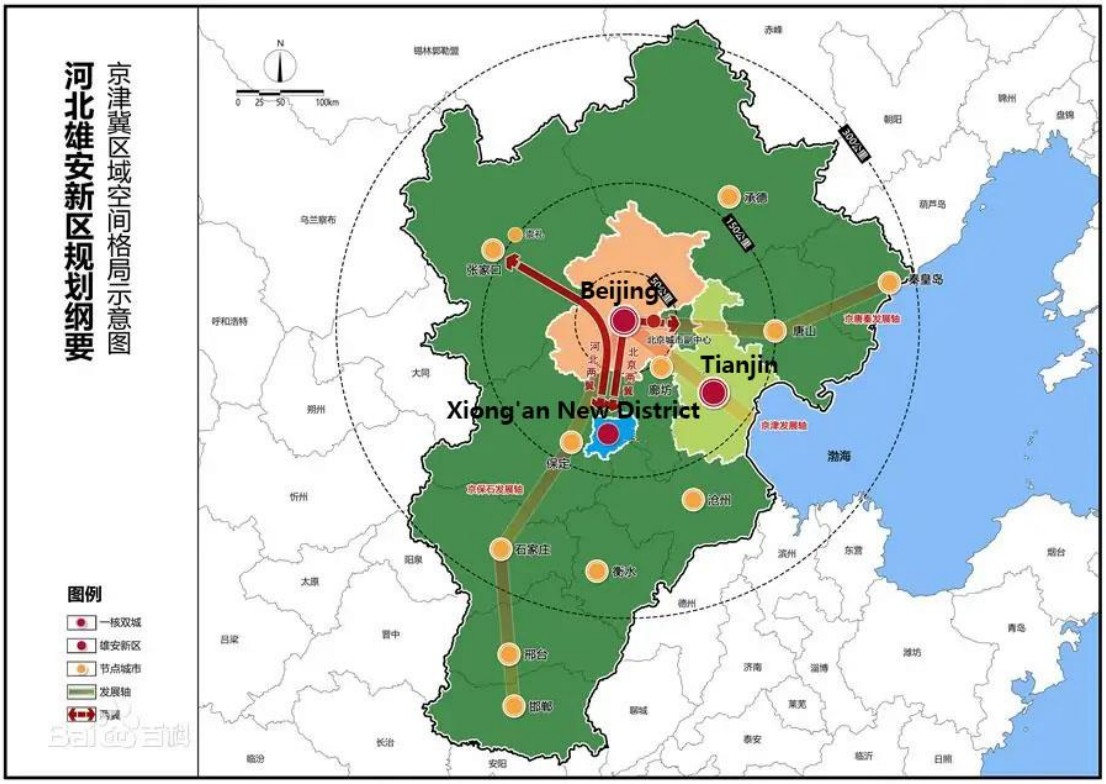

Figure 12- Beijing-Tianjin-Hebei regional spatial pattern diagram
Source: Hebei Xiong'an New Area Planning Outline

2.3 Problems of the Chinese new town

Nationally, China's new towns show a growing number, expanding area and uneven regional distribution. According to incomplete statistics, as of 2018, the number of new towns in China exceeded 3,800, including 20 national-level new zones, 552 national-level development zones, 1,991 provincial-level development zones, and 1,284 new towns below the provincial level. The average planned area of new towns in China is 37 square kilometers, the average planned construction land is 19 square kilometers, the average planned population is 110,000, the average built area is 7.6 square kilometers, the average current population is 40,000, the average completion rate is 55%, and the average planned population realization is 36%. In terms of regional distribution, the eastern coastal region accounts for 13 of the new towns with an area of over 1,000 square kilometers, and the current new town construction is mainly concentrated in the eastern region (Figure.13).

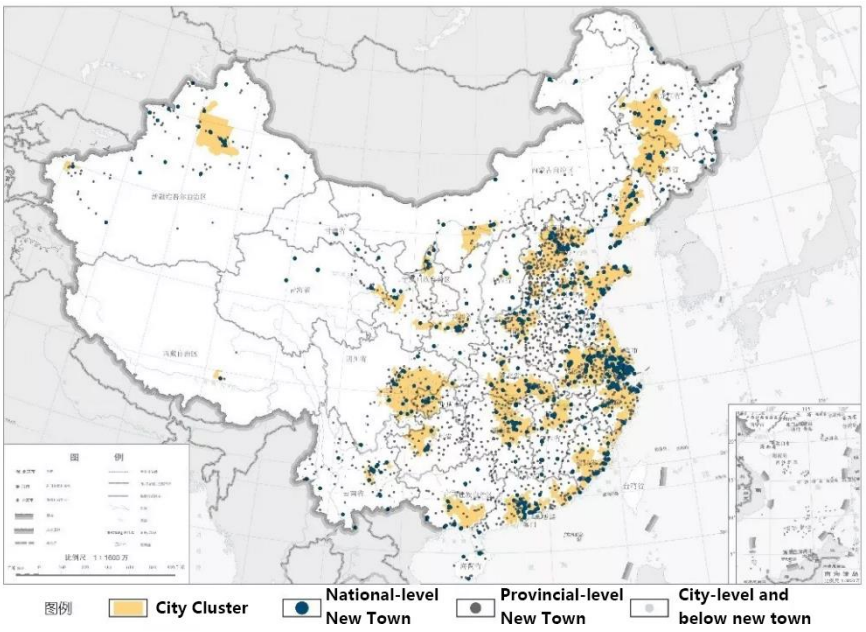

Figure 13 - The relationship between the spatial distribution of New towns and major urban agglomerations in China
Source: White Thesis on the Planning and Construction Management of New Towns in China

In China's large-scale new town construction, there are several other problems: waste of land, environmental damage, over-construction, separation of industry and urban development, and blurred or homogenized functional positioning of new towns.

2.3.1. Waste of land

At present, municipalities directly under the central government, cities listed in the plan and provincial capitals have commonly built new towns, most prefecture-level cities have also planned and built new towns, some county-level cities and counties are also planning and building new towns, and some cities even have multiple new towns at the same time. The uncontrolled failure of scientific planning has led some new towns to be greedy for more and bigger in the construction. According to the "National New Town New District Planning and Construction Management White Thesis" issued by the China Academy of Urban Planning and Design in 2019, some new towns have planned an average annual land

increment of more than 30 square kilometers, and some new towns have planned land increments of more than 50% of the current built-up area of the city in which they are located. Due to the general oversize of new city construction, 42% of the new town land construction area has greatly exceeded the approved urban construction land control index. Some new towns even greatly exceed the area of the old city, wasting valuable land resources. There are several reasons for this evil result: the upper statutory plan (district and county general plan) breaks through the general plan of the city where it is located, the control plan is not adjusted in time after the adjustment of the upper statutory plan, and the non-statutory plan (strategic plan) is used as the basis to break through the statutory plan, etc.

The waste of land in new town construction is not only the blind pursuit of urban scale, but also the idle and inefficient use of land in new towns. The completion rate of new towns in eastern China is generally high, with the basic completion rate of new towns in Shanghai, Shenzhen and Changchun exceeding 80%. However, the completion rate of new towns in the western region is lower, with an average completion rate of about 48%. About 10% of the surveyed development zones have a completion rate of less than 40%. The per-place economic output of some national-level development zones is extremely low, very much out of line with their positioning and requirements.

2.3.2. Environmental damage

In China, most of the new town development mainly relies on occupying the original agricultural land or the natural landscape at the edge of the mother city. In recent years, due to the blind pursuit of fast pace of urbanization by local governments, the construction of new towns has occupied a large amount of arable land without regard to the rational use of rural resources and the protection of ecological environment, with the consequent increasing prominence of resource and environmental problems (Bai, 2010). For example, the natural and semi-natural landscape is seriously damaged due to the interference of

human behavior, lack of continuity, and the original ecological level is broken; the natural landscape lacks reasonable planning, the landscape fragmentation is serious and the accessibility is reduced; the rural landscape resources are used roughly, the soil erosion of idle land and the surface pollution of farmland are serious; the biodiversity is damaged, the ecological security is threatened and the aesthetic value is reduced, etc.

Natural environment is the basis for human survival and development. In the natural environment topography and geomorphology, rivers, lakes and wetlands, natural vegetation and other elements are the main landscape resources of the city, and also the landscape foundation of new towns. However, in the construction of many new towns, a large number of artificial landscapes have replaced the natural landscapes, large artificial lawns have replaced the sky-high trees, and large ground hardening makes it difficult to reveal the natural landscapes, all of which make the urban environment has been far away from nature.

2.3.3. Construction overruns

In sharp contrast to the new town construction fever is the small population size of new towns in some cities, which leads to the construction of new towns exceeding the actual population needs. At present, among the 1284 new towns below the provincial level in China, the majority of them have a population of several hundred thousand, and some of them have a population of less than 100,000, or even less than 10,000. Taking the planning of airport new towns as an example, the existing airport new towns in China are generally large in planning area, most of them exceed 100 square kilometers, far beyond the scope of successful international airport city development. However, a large number of airports have far less than 10 million passenger trips and do not have the strength to drive the development of the surrounding areas. The small population size of new towns not only restricts the construction of infrastructure such as transportation, water supply, power supply, communication, sewage and garbage disposal, but also causes wasteful and inefficient use of completed infrastructure.

On the other hand, this kind of new town construction ahead of time also increases the risk of indebtedness of local governments. The construction of new towns involves a full range of infrastructure construction, which will generate huge investment needs, and the capital demand is very large. Some new town development and construction investment needs are often tens of billions of yuan or even hundreds of billions of yuan, far beyond the city's investment and financing capacity. Many cities compete to raise debt financing through local government financing platform companies, which has led to the expansion of the number of local government financing platform companies, the scale of debt has soared.

Although some new towns are ahead of their time in infrastructure construction, their excessively small population hinders the entry and growth of commercial, educational, medical, catering, entertainment and other service facilities and functions, making it difficult to form a continuously expanding and upgrading consumer demand and service demand. This has caused the new town to lack popularity and commerciality for a long period of time, defeating the original purpose of the new town to absorb the population and develop the economy. Such new towns are huge, hollow and useless (Woodworth and Wallace, 2017).

2.3.4. Separation of industry and urban development

The industry of some new towns is not well integrated with the city. There are two reasons for this phenomenon: 1. the industrial base of new towns is weak and cannot drive urban development; 2. the living support function of new towns is seriously lagging behind, which leads to the separation of people's work and living.

Among the series of new towns currently under construction in China, some rely on the industrial base of old cities, some rely on their own existing development zones, while some have no industrial base and need to cultivate an industrial system again on an undeveloped land. Although local governments have formulated plans for the industrial development of new towns, there are still many uncertainties and risks in investment attraction, industrial selection, and competition with main city industries. A part of urban

new towns are difficult to form a competitive industrial system in the short term due to relatively poor infrastructure conditions and insufficient industrial supporting capacity. With a weak industrial base, it will not be able to create stable employment and attract population gathering, and it will be difficult to sustain the cultivation and performance of production and service functions, and the construction and development of new towns will inevitably lack internal motivation and effective support.

Another situation is that the new town lacks urban functions other than employment, so people can only commute between the main city and the new town every day. This will bring serious commuting traffic pressure, and at the same time lead to a lower sense of happiness and a less attractive new city. At present, some new towns in China are extremely lagging behind in the construction of living public facilities and cannot meet the basic needs of living services; some new towns have low construction level and spatial quality and lack attractiveness; and some new towns are mainly built by putting industrial land, which squeezes out the land supply index of other types of land.

The separation of industry and urban development in the future will also seriously restrict the future transformation and upgrading of new towns.

2.3.5. Blurred or homogenized functional positioning

Many new towns are not really "new" in the sense that they do not form a mutually supportive and complementary situation with the original old town. Some of the new towns are not clearly positioned, and to a large extent, they are only strategically shifted to relieve the huge pressure of housing, traffic and resources and environment in the old city, and the urban functions of the new towns and the old city gradually converge. Even some new towns have great uncertainty in the program during the planning period. The new town space is like an empty space that can be filled with various urban functions at will (Governa & Sampieri, 2020). There are also new towns that gradually deviate from the original planning intention during the construction process. All kinds of phenomena have caused serious

duplication of facilities and waste of resources, adding a new heavy burden to the local government's finance, commuting, and management.

Functional positioning is also related to the spatial pattern of new towns. Different urban functions have different requirements on land, environment, clusters, etc., and thus have certain requirements on urban spatial conditions (Wang, 2006). The functional positioning of new towns requires urban spatial development strategies to correspond to it. However, some new towns have failed to form an organic system due to their vague functional orientation. The new towns are a disconnected and weakly connected existence to the old towns. Perhaps in the future, these vaguely positioned new towns will become a convergent urban space with the old city, not only failing to improve the spatial pattern of the old city, but also encountering bottlenecks in their own development.

On the other hand, some new towns are homogenized despite their clear positioning. One example is the serious overlap of the industrial positioning of the port in the Beijing-Tianjin-Hebei region, where the industries of the Binhai New Area, Caofeidian New Area, Bohai New Area and other new port towns are highly similar, and all of them are mainly low-end industrial and manufacturing industries. In addition, high-speed railway new towns have become the hot spot of development in recent years, but most of them are located in the sub-center of the city, from which the functions of business and finance, culture, leisure and entertainment, residence and administrative office are further analyzed, thus many high-speed railway new towns have the same or similar functions. The uniform planning makes the urban landscape of each new town look identical, lacking uniqueness and creativity.

2.4 Underground space in new town

It is clear from the above that the existence of new towns brings benefits and opportunities to urban development, but along with the construction of new towns, many problems have arisen. Therefore, this paragraph attempts to discuss solutions to address

the challenges faced by new towns through the development of underground space, starting with the functions and characteristics of underground space, and then using them to explore the possibilities of underground space to improve the development of new towns.

2.4.1 Functions and characteristics of underground space

Underground space is considered to be one of the most valuable natural resources that mankind has not yet fully exploited, and also has irreversible use characteristics. Urban development has taken place over thousands of years in human history, but large-scale, orderly underground space development has been concentrated in the last few centuries. From ancient times to the present, many urban planners have considered building underground space to compensate for serious urban problems in old cities. In contrast, if the development and use of underground space is carefully considered at the beginning of new town construction, it can help to avoid past problems when new towns are developed. In turn, it will promote the safe, sustainable and vibrant growth of new towns and ultimately improve the quality of urbanization.

With the deepening of people's understanding of urban underground space for hundreds of years, more and more functions have been developed and utilized. Bobylev (2009) summarizes the certain natural peculiarities or characteristics of urban underground space and shows the corresponding usage example (Tab.4). The agglomeration of urban development and the advancement of architectural techniques have also promoted the development of underground space functions from points, lines, and networks to the three-dimensional and systematic use of space (Yuan, 2017). At present, the functions of urban underground space mainly include the following: storage (e.g., food, water, oil, industrial goods, waste); industry (e.g., power plants); transport (e.g., railways, roads, pedestrian tunnels); utilities and communications (e.g., water, sewerage, gas, electric cables); public use (e.g., shopping centers, hospitals, civil defense structures); and private and personal use (e.g., car garages) (Bobylev, 2009). Urban underground infrastructure (UUI)

is the core of underground space utilization. Underground infrastructure is defined as a series of underground structures interconnected either physically or functionally (Bobylev, 2007; Sterling et al., 2012). Zargarian (2017) divides UUI into two categories:

1. Functional infrastructures: which include utilities, storage facilities and energy exploitation. These facilities are designed to smoothly deliver resources and surplus output through the city and support the city's daily functions.
4. Passing and living spaces include transport networks, underground stations, and sub-surface recreational centers. This type of UUI serves people and provides space for various human activities, such as walking through or short stays (Jefferson et al., 2006; Parriaux et al., 2006).

Characteristic	Description	Examples of underground structures
Isolation	Underground spaces are less susceptible to external influences, and their impact on the external environment is less than aboveground facilities (e.g. noise).	Energy supply facilities.
Temperature stability	Less need for heating or cooling: in many cases underground facilities do not require any temperature adjustment at all.	Storage, civil defense shelters.
Protection	Underground spaces have limited areas of connection with the outside, and flow or movements through these connection areas are easy to control.	Civil defense, valuable or hazardous goods storage.
Vulnerability to floods	Inundation can cause severe and unpredictable damage to underground structures, e.g. the floor structure of an upper level can collapse under the weight of water.	Measures to manage flooding: waterproof and semi-waterproof doors, emergency drainage tunnels and reservoirs, pumping stations.
Resilience during earthquakes	Deep underground structures suffer significantly less damage during earthquakes than aboveground structures.	Storage facilities, civil defense shelters, emergency response centers.
High cost of construction	Construction cost is highly dependent on ground conditions.	Underground structures are planned for many years of operation (usually 100–300 for public infrastructure).
Low cost of operation	No maintenance of outer walls is needed, low cost of heating/cooling. Some extra costs for ventilation and emergency prevention and response systems.	Vast range of public structures, particularly in regions with severe climate.
Opportunity to locate close to existing facilities	In urban areas, surface space is very often already occupied by valuable developments, and underground space is the only available location for new facilities in the required area.	Transport and emergency response infrastructure.

Table. 3 - Major characteristics of underground space

Source: Nikolai Bobylev, 2009, Mainstreaming sustainable development into a city's Masterplan: A case of Urban Underground Space use

Based on the various services that the underground space can provide to humans, Parriaux et al. (2006) classified urban subsurface resources into four categories (Fig. 14):space (place for building and infrastructure construction), geomaterials (mainly issued from underground excavations), groundwater, for drinking or industrial purposes (aquifers at different depth) amd geothermy (shallow and deep geothermal systems).

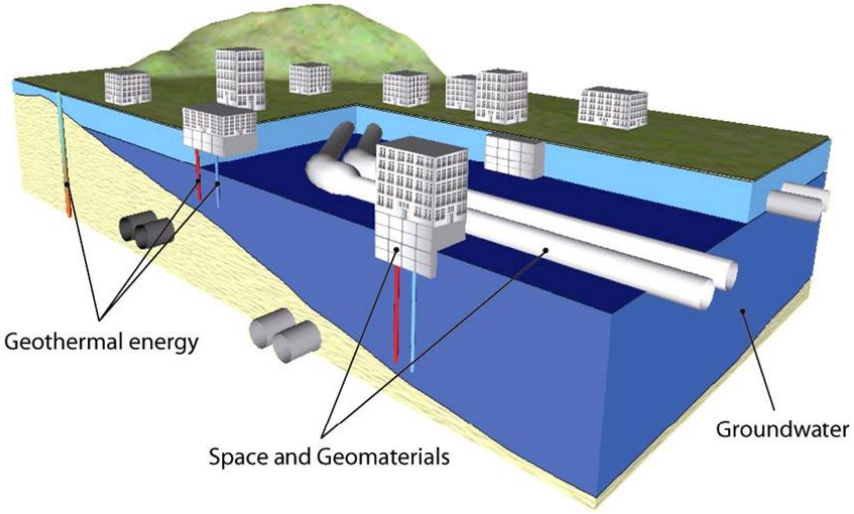

Figure 14 – The four main resources of the citys underground

Source: Blunier et al., 2006, Underground resources and sustainable development in urban areas.

In addition, Bobylev (2009) adds two perspectives to the classification of urban underground space resources:

1 Renewable services/resources (Physical space, Space continuum that has certain soil strength properties, Excavated materials)

2 Non-renewable services/resources (Groundwater, Geothermal energy, Cultural heritage);

3 Passively utilized services/resources (Space continuum that has certain soil strength properties, Groundwater supply for surface vegetation, Surface water reserves supplied by groundwater, Cultural heritage.)

4 Actively utilized services/resources (Physical space, Excavated materials, Drinking water supply, Geothermal energy, Cultural heritage)

Later Bobylev (2018) further expanded the scope of underground resources to geosystem services, covering everything buried underground, including food and water, energy and materials, rocks and soils, organisms, culture, archaeology and mineral deposits.

Underground facilities have a longer life cycle than aboveground facilities by

eliminating much of the environmental exposure. In addition, resilience is an integral part of what makes a city sustainable in the long term, with underground structures being well equipped to withstand catastrophic events. Overall, they are more competitive than aboveground facilities (Sterling et al., 2012).

2.4.2 The role of developing underground space for the new town

Obviously, the development and utilization of urban underground space is the main focus point for transforming urban development, governing sustainable urban development, resilience and ecological security issues (ACUUS, 2019). The rational construction of underground space makes outstanding contributions in improving the efficiency of new town land, stimulating the vitality of new town development, guaranteeing the safety of new town, and creating a good landscape environment of new town.

2.4.2.1 Improving the efficiency of land use in new towns

New towns are important carriers for urban space expansion and promoting urbanization, but some new towns are built with disorderly expansion, resulting in the bad consequences of wasted land resources and low-quality urbanization.

Even though new towns have more space for construction than old towns, they should consider developing compact cities to promote sustainable development of new towns and try to avoid today's new towns becoming old towns with many problems in the future. The compact city theory (1973) promotes the following three main ideas: high-density development, mixed land-use, and prioritization of public transportation, among others. The use of underground space for infrastructure, resulting in three-dimensional compact urban areas, can provide obvious environmental benefits, reducing energy consumption and air pollution, and lowering infrastructure costs while being more dynamic and social than scattered cities (Besner, 2002).

The development of underground space contributes to the realization of compact cities in new towns (Bobylev, 2016) and has a great potential for development in terms of efficient land use. Construction of underground space can expand the spatial capacity of the new town in areas that do not increase the number of buildings on the ground. And because it is not restricted by daylight and the red line of ground planning, underground space can be arranged densely, further improving the efficiency of land use in the new town. Various urban functional spaces are laid out above and below ground in a three-dimensional manner, thus forming a compact urban pattern, improving land use efficiency, and preventing the new town from becoming too large. The development of underground space in the central area of the new town promotes the agglomeration of various urban functions, which is equivalent to creating more social wealth and comprehensive benefits with as few resources as possible. With such a clustering effect, the vitality of the new city center is increased and the growth of the new town is stimulated.

2.4.2.2 Energize the development of new towns

In urban design, an urban catalyst is a new element that can cause changes in the city and accelerate or change the speed of urban development and construction. In other words, through the intervention of a specific catalyst element, a certain "chain reaction" is triggered, leading to the maturation of the objective conditions for urban construction, thus promoting the continuous and progressive optimization of the city. Underground space with specific functions can be one of the catalysts for the development of a new town, stimulating the city's vitality and enabling it to develop continuously. For example, the business developed by relying on the comprehensive underground rail transit hub can not only gain high commercial profits, but also promote the development of the surrounding areas, and lead various capitals including real estate, hotels and restaurants to enter spontaneously under the action of market mechanism and value law, thus triggering large-scale urban

development in the surrounding areas (Wan, 2013).

Underground space has great potential for developing transportation systems and housing the commercial, cultural and entertainment functions of cities. New town construction can enhance urban accessibility by developing underground transportation systems; and increase urban living service space by establishing underground buildings of shopping, cultural, and entertainment nature. Some new towns are growing with industrial development alone, but lack urban development. The underground space with high accessibility and perfect living service facilities can effectively enhance the attractiveness of the new towns, and have a radiating effect on the surrounding urban space, promoting the common development of the working and living functions of the new towns, and finally achieving the purpose of absorbing the population and sustainable urban development. Ultimately, the composite underground space development can make the new town evolve into a multi-functional complementary and vibrant urban "life body".

2.4.2.3 Safeguarding the safety of new towns

Unlike above-ground spaces, which are exposed to the natural environment and are permanently affected by human activities, underground spaces are surrounded by rock and soil and have a certain thickness of cover, so they have excellent performance in thermal insulation, thermal stability and confinement. At the same time, underground space has high protection. With certain engineering protection measures, the space has the ability to protect against various modern weapon attacks with the corresponding measures. Such as the main effects of nuclear weapons such as light radiation, nuclear radiation, air shock waves, radioactive contamination, etc., underground space can be effective protection. This high level of protection is not only against the threat of war, but also effective in reducing the harm to humans from natural disasters. Generally speaking, external disasters such as earthquakes, explosions, fires, poison prevention, wind disasters, etc., underground space

only needs to take certain measures to achieve a strong protection effect (Zhou, 2005). In case of seismic disasters, the underground space has lower seismic intensity than the surface, and the underground geotechnical soil can provide elastic resistance to the underground building structure and stop the structural displacement. At the same time, the underground space plays a damping role to the structural self-oscillation and reduces the structural amplitude. When an earthquake occurs, as long as the entrance and vertical traffic are not destroyed or blocked, safety can basically be ensured. Another example is that when a fire occurs, the hot gas flows upward and does not spread downward easily, so the fire that occurs on the ground can ensure the safety of people as long as the entrance and exit protection measures are ensured (Wang, 2013). Due to the various advantages of underground space, people have built various air defense facilities and disaster prevention facilities in underground space, and these have been utilized to protect the safety of cities.

Many cities have experienced numerous natural disasters and war threats in the course of centuries of development, and have gradually formed more complete underground disaster prevention and air defense facilities. Evacuation emergency sites, access roads, shelters, resource reserves, emergency hospitals and other facilities have been built using underground space. Chinese new towns are often built on the periphery of large cities or developed from township development areas, which were not planned by urban builders as priority areas for air and disaster prevention in the past and lacked appropriate safety facilities.

However, in the future, the new town will absorb a large number of people to move in, and the use of underground space to build security facilities can effectively protect the safety of citizens. Although it is impossible to predict the future form of international security, the construction of underground air defense facilities is the basis for protecting the residents of the new town. In addition, the problem of natural disasters, which is closely related to people's production and life, is one of the necessary reasons for building underground space in new towns. Among the natural disasters, earthquakes, fires and winds can be reduced mostly due to the characteristics of the underground space itself, but floods

may pose a greater threat to the underground space. However, through careful planning, underground space can be used to store flood water and thus mitigate the impact of flooding on cities. In the context of rapid global climate change and the frequent occurrence of various natural disasters, new towns should make effective use of the characteristics of underground space to develop it rationally so as to protect the lives and properties of the people in the new towns.

2.4.2.4 Create a good landscape environment in the new town

To create a good landscape environment in the new town construction, the required above-ground space can be reduced by underground space development. Avoid taking up ecological green space, wetlands and high quality and productive agricultural land in the district, and reduce the environmental damage caused by the construction of new towns.

New cities still have the opportunity and ability to preserve their original landscapes than old cities, so city builders should respect and reinforce the natural landscape character of the city itself when planning new towns, and use underground space to achieve this purpose. Before construction, buildings whose functions are adapted to underground space, such as museums, art galleries, etc., can be moved underground to reduce the occupation and disturbance of surface space. This will not only maintain the ecological balance of the local area and promote sustainable development, but also preserve the original vitality and vigor in the hard space of the city.

In addition, during the construction process, although underground space will produce more pollution than above-ground buildings, after completion, the pollution of underground space to the environment is far less than that of above-ground buildings, and the subsequent maintenance cost of underground space is also much lower than that of above-ground buildings. Underground space for new town development not only promotes sustainability in the environment, but also saves some money.

Chapter 3 Case study: Nanqiao new town

Nanqiao new town is located in Nanqiao District, Chuzhou City, Anhui Province in eastern China (Figure.15). The current area of Nanqiao new town is 96.3 square kilometers, of which the urban area is 30 square kilometers in 2020, and is expected to reach 36 square kilometers in 2030, with the prospective land scale controlled within 50 square kilometers. The population of Nanqiao new town is 200,000 in 2020, and is expected to reach 300,000 in 2030 and 500,000 in 2050. The urban nature of Nanqiao new town is the deputy center of Chuzhou City, the economic, political and cultural center of Nanqiao District, a modern inter-provincial border city with new industries such as high-tech, trade and logistics, leisure and vacation.

Figure 15 - Location of Nanqiao new town in China.

Source: Elaboration by author

3.1 Natural Environment

Nanqiao new town is located in the north subtropical monsoon climate zone, with mild climate, four distinct seasons and sufficient sunshine. The frost-free period is long (220 days on average for many years), and the dominant wind direction is easterly all year round,

mostly southeasterly in summer and northwesterly in winter. The rainfall here is moderate, with an average annual precipitation of 1018.6 mm from 1993 to 2020. Nanqiao new town belongs to Jianghuai hills, the northwest is a hilly and gently sloping area with a slightly higher elevation, and the southeast is a flat polder area with low lying terrain. Nanqiao new town in the northeast Qingliu River surrounds the southeast and Nanjing Pukou District is divided by the Chu River. There is also a scenic Huangqing Lake in the new city, with a well-protected wetland landscape.

However, due to the development of heavy industry in Nanqiao new town in previous years, the natural ecology near the industrial area has been damaged, and the government was currently trying to take measures to restore it.

3.2 Urban development

Chuzhou City, to which Nanqiao new town belongs, has a long history. In 1917, Chuzhou District was renamed Chu County, and in 1982, Chu County was abolished to establish the county-level Chuzhou City, and in 1993, the State Council approved the change to the provincial jurisdiction of Chuzhou City, making Nanqiao District one of the two jurisdictions of Chuzhou City. Nanqiao District has 8 towns and 4 street offices, including Wuyi Town, Shahe Town and Zhulong Town, with a total of 59 administrative villages and 32 communities (25 urban communities + 7 rural communities). Nanqiao new town is a new town developed on the basis of Wuyi Town.

Wuyi Town is the first town in Nanqiao District, but before the reform and opening up, it was just an old street town with an area of 0.2 square kilometers and a population of less than 3,000 people. Since the reform and opening up, the town has been vigorously implementing the "three strategies" of industrialization, urbanization, eastward development and the construction of a beautiful countryside, resulting in rapid and healthy economic and social development. At the beginning of 2009, Wuyi Town was also established as the first level of government in Nanqiao District, with a total planning of

400,000 square kilometers. In 2010, Wuyi Town was identified as a pilot town of decentralization and a model town of New Village in the province. 145.5 square kilometers of town area in 2016, including 4.68 square kilometers of market town area. The total population of the town is 62,000, of which 28,000 are in the township. The rapid development of Wuyi town also added to the construction of the "big Chu City" later.

In 2004, the "Chuzhou City Master Plan (2004 ~ 2020)" was the first to put forward the concept of " Great Chu City ", that is, the main urban area of Chuzhou as the center, to An, Quanjiao, Wuyi as the three sub-centers, to Langya Mountain scenic area as the backbone, and national roads, provincial roads, highways, urban expressways as a transport link.In the planning period to form a dense belt spatial structure of Great Chu City. In the planning period to form a dense belt spatial structure of greater Chu City. The ultimate goal of the plan is to create a prosperous economy, mountain and water, ecological beauty, people and livable new Chu City. In the group development plan of Chuzhou City, located in Wuyi Nanqiao new town has become an important pole of urban construction. 2010 Chuzhou Municipal People's Government adopted the "Chuzhou City Wuyi (Nanqiao new town) master plan (2010-2030)" (adjusted in 2021) marked the establishment of Nanqiao new town (Figure.16-17).

Figure 16 - Nanqiao new town satellite map

Source: Baidu Map

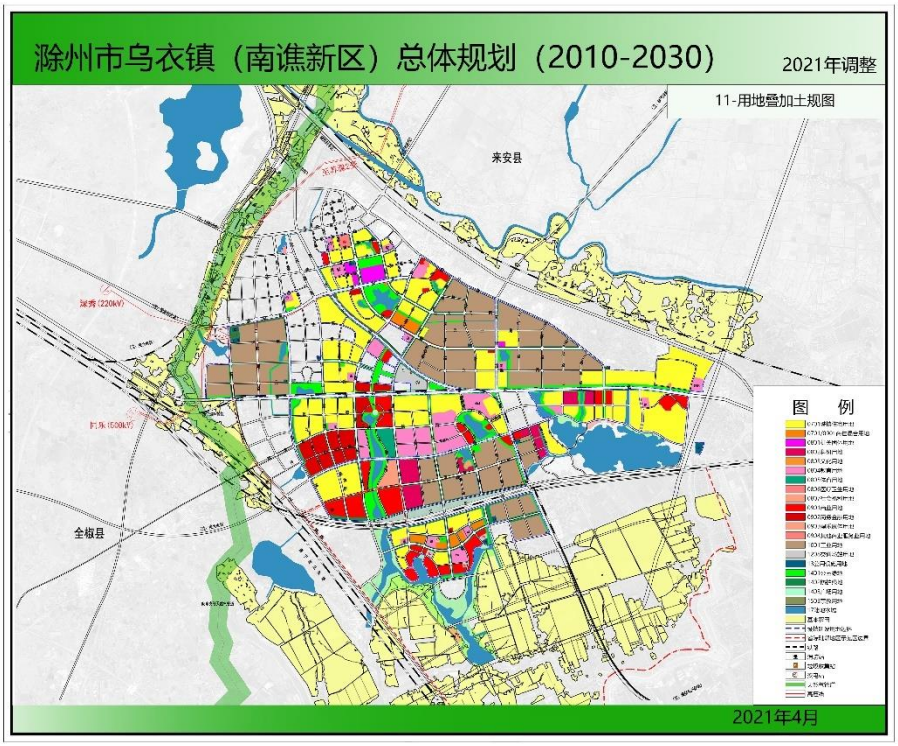

Figure 17 - Adjustment of land layout of Nanqiao new town

Source: Chuzhou Wuyi (Nanqiao new town) Master Plan (2010-2030) (adjusted in 2021)

Under the implementation of the current master plan, Nanqiao new town has formed a scale of agglomeration effect, has a certain construction foundation and development pattern, the initial effect of industrial agglomeration has appeared, and the quality of the city has improved. According to the statistical bulletin of national economic and social development of Nanqiao District in 2020, the GDP of Nanqiao new town in 2020 is 17.68 billion yuan, the per capita GDP is 88,400 yuan, and the structure of three industries is 8:42:50, which is a more developed area in Chuzhou City. But the development of Nanqiao new town also has some shortcomings, first of all, the future of major regional facilities changes are not enough to respond to the north along the river high-speed rail and Chu-Ning intercity railroad, reserved for the articulation is not enough. Secondly, there are differences between the planning and the current site, the site is scattered, resulting in waste. So in 2021

on the "Chuzhou City Wuyi (Nanqiao new town) master plan (2010-2030)" was adjusted, the future planning ideas are mainly.

1. Promote the unification of multiple planning cooperation, coordinate various types of spatial resources, and realize the efficient use of spatial resources.
2. Implement the development orientation of a new functional area in the Pukou-Nanqiao cross-border inter-provincial adjacent area to support the Nanjing-Chuzhou co-city. More focus on the integration and efficiency of infrastructure, innovation system synergy and common construction, industrial specialization and division of labor, public services, common construction and sharing, ecological and environmental protection and governance, and urban-rural integration and development (Figure.18).
3. Not to break through the urban construction land index and strictly comply with the basic farmland protection requirements.
4. Optimize the layout of living space and build the concept of living circle; accelerate the equalization of basic public services and ensure that the total amount of public welfare facilities will not be reduced.

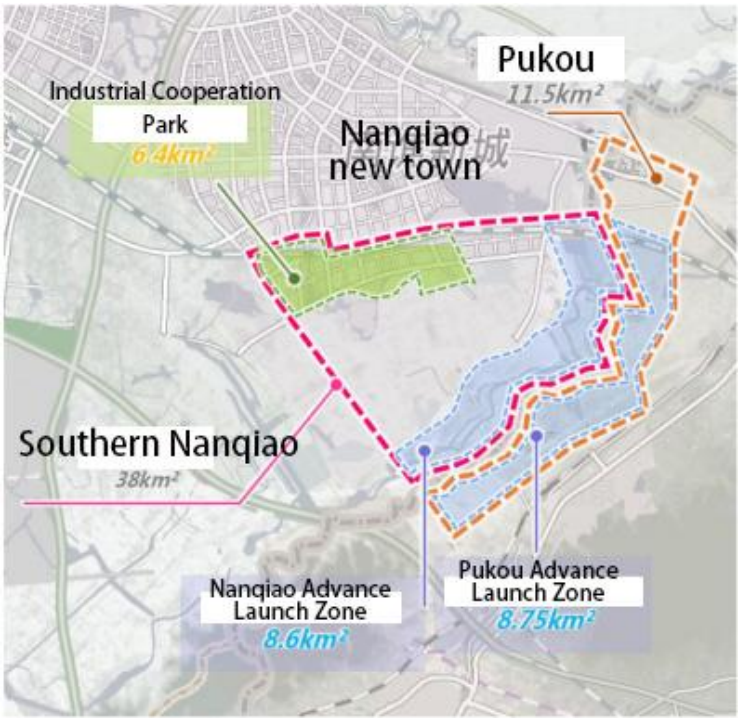

Figure 18 - Pukou-Nanqiao Cross-border Inter-provincial Adjacent Area New Functional Area Development Orientation Map

Source: Chuzhou Wuyi (Nanqiao new town) Master Plan (2010-2030) (adjusted in 2021)

3.3 Traffic conditions

Nanqiao is a new town established at the junction of Anhui Province and Jiangsu Province, 11 kilometers from the main city of Chuzhou in the north and 30 kilometers from the main city of Nanjing in the south. Nanqiao new town is the key area of Anhui Province's "eastward development" strategy (Figure.19). Because of its vast hinterland and strong carrying capacity, it is a frontier area for integration into the Nanjing metropolitan area and liaison with Pukou District (a district of Nanjing, bordering Nanqiao new town). Nanqiao new town northwest of the Beijing-Shanghai railroad, Ma Chu Yang high-speed surroundings, Chu Ning Expressway through the town, location advantages and convenient transportation make Nanqiao new town economic development rapidly.

Although Nanqiao new town is close to Nanjing, but the public transportation between the two cities is still weak, only one type of bus. According to the "Chuzhou City Comprehensive Urban Transport Planning (2012-2030)", within the scope of Nanqiao new town will be Chu-Ning Express Line S4 (Chuzhou-Nanjing) from west to southeast through the south, the establishment of three stations, respectively, Yuanshan Park Station, Science and Technology City Station and Huang Wei Road Station. line S4 in the scope of Nanqiao laying method is not clear whether above ground or underground.

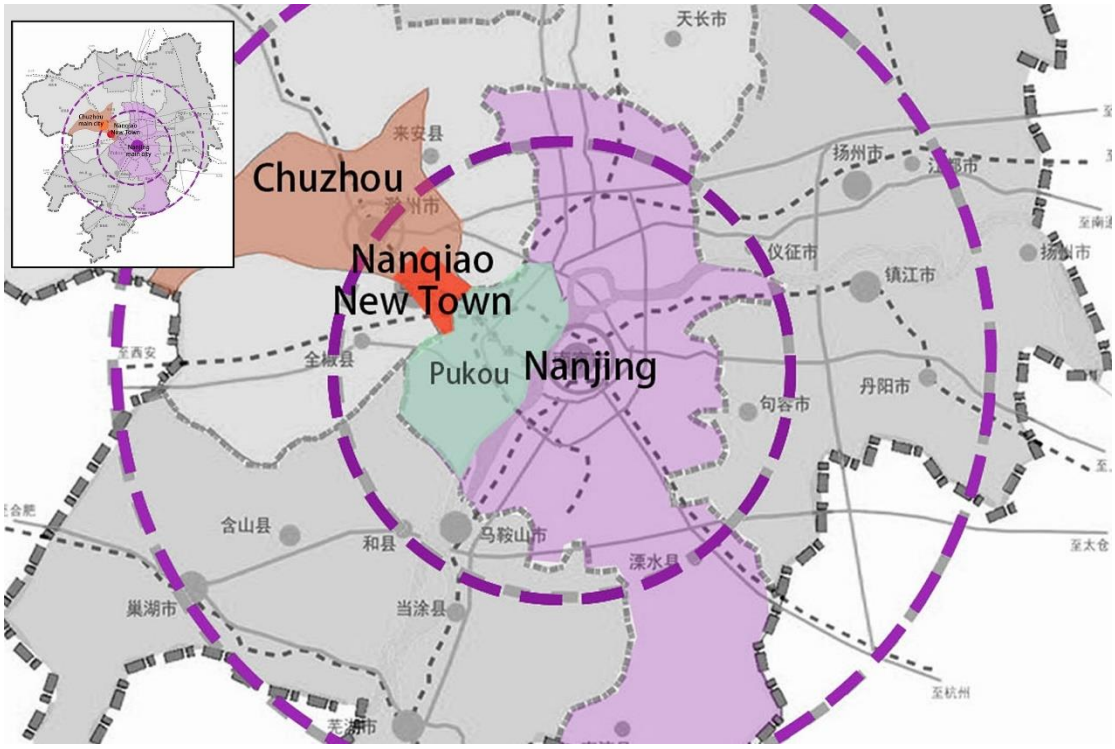

Figure 19 - Location of Nanqiao new town in Nanjing Metropolitan Area

Source: Elaboration by author

3.4 Industrial Dependence

3.4.1 Nanqiao Economic Development Zone (Wuyi Park)

In 2007, before the establishment of Nanqiao new town, Wuyi Town built Wuyi Park, which belongs to Nanqiao Economic Development Zone. Nanqiao Economic Development Zone was originally named Nanqiao Industrial Development Zone, which was planned and built by Nanqiao District Government in June 1999 under the environment of "development zone fever". In 2018, Nanqiao Industrial Development Zone was renamed as Nanqiao Economic Development Zone.

The industrial positioning of Nanqiao Economic Development Zone is machinery, agricultural and sideline products processing and home appliance industry. The overall area of the zone is 45.5 square kilometers, which currently includes four zones: Chengnan, Waipu, Wuyi and Dawang, and the new Wuyi Zone, which was established in 2007, is the key

development zone of Nanqiao Economic Development Zone. Wuyi Park is located in the eastern part of Nanqiao new town, with a planning area of 6.74 square kilometers and a current built-up area of 4.58 square kilometers. Wuyi Park is only half an hour's drive from downtown Nanjing via the river tunnel, 60 km from Nanjing Lukou Airport, and 40 km from the largest domestic inland river port of Xinxingwei Port, making it a convenient transportation and superior location. The industrial positioning of Wu Yi Park is to drive the economic development of the park by the market, mainly attracting machinery processing, high-end precision manufacturing and new energy projects to the park.

By the end of 2015, the total number of investment enterprises in Nanqiao Economic Development Zone reached 260, including 55 industrial enterprises above the scale, with a total output value of 7.313 billion yuan, an increase of 22.18% year-on-year, including 7 high-tech enterprises, with a total output value of 938 million yuan, accounting for 12.83% (the proportion of output value of high-tech enterprises in the total output value of industry on the scale (The proportion of the output value of strategic emerging enterprises to the total output value of industry on the registry); 11 strategic emerging enterprises, the cumulative output value of 1.896 billion yuan, accounting for 25.93% (the proportion of the output value of strategic emerging industry enterprises to the total output value of industry on the registry). The value added of the above industry is 1.808 billion yuan, an increase of 21.02%; the total import and export is 36.09 million U.S. dollars, an increase of 27.08%; the fixed asset investment is 6.765 billion yuan, an increase of 26.1%; the tax revenue is 618 million yuan, an increase of 26.38%. The initial formation of special equipment manufacturing, electrical machinery and equipment manufacturing, instrumentation manufacturing to become the three leading industries in the development zone, the leading industries in 2015 to achieve a total industrial output value above the scale of 3.38 billion yuan, accounting for 46.22% of the total industrial output value above the scale of the region. Since 2011, in Chuzhou City, 14 provincial-level and above development zones in the target assessment, Nanqiao Industrial Park ranked in the forefront for many years. 2020, the Anhui provincial government issued the "Notice on the results of the comprehensive assessment

and evaluation of the province's development zones in 2020," in which Nanqiao Economic Development Zone ranked fifth in the province.

3.4.2 Chuzhou Hi-Tech Innovation Park

Chuzhou Hi-Tech Innovation Park planning area of 30 square kilometers, located in the heart of Nanqiao new town, 18 kilometers east of Nanjing Jiangbei New Area, 18 kilometers west of the main city of Chuzhou, 30 minutes drive to six highway imports and exports, a 10-minute drive to the Beijing-Shanghai high-speed railway Chuzhou station, the planned Chu-Nanjing light rail line will pass through the border.

As the city's "cross-regional collaborative innovation experimental zone, the transfer of scientific and technological achievements into a pioneering area" innovation platform, Chuzhou Hi-Tech Innovation Park adhering to the "production, life, ecology" concept of integration of the three lives, following the "research, production, learning, city "four in one, to explore the "higher education + science and innovation + industry" integration of the mode of mutual growth. Chuzhou Hi-Tech Innovation Park uses preferential policies for domestic and foreign institutions of higher learning, research institutes, well-known enterprises, the introduction of talent, technology and capital.

As of 2021, Chuzhou Hi-Tech Innovation Park has invested a total of more than 7 billion yuan, and has initially built an "L-shaped" development framework with three large areas closely linked, namely the Huizhi Bay area, the unmanned systems intelligent manufacturing demonstration area and the South Engineering University R&D area. It has completed and put into use 186,000 square meters of incubators and innovation and entrepreneurship carriers; 240,000 square meters of production facilities such as gas pedals; 260,000 square meters of living service facilities such as talent apartments, and cultural & sports centers; 960,000 square meters of green ecological facilities such as parks; and more than 30 kilometers of roads in the park. Since 2017, a total of 34 projects of more than 100 million yuan have been signed and landed, with universities and institutes such as Nanjing

University of Technology, Anhui Institute of Science and Technology, Changchun Institute of Optics and Machinery of Chinese Academy of Sciences, innovation entities such as Xi'an Jiaotong University National University Science and Technology Park and Beijing Zhongguancun Development Group, and high-tech and high-services projects such as Feng Shu Modern Integrated Industrial Park, Huayun Big Data and Dongzhou Electronics. High-tech and service-oriented projects have been stationed in the park. Cumulative attraction and training of high-level talent 107.

Chuzhou Hi-Tech Innovation Park was also established in Chuzhou University Science and Technology Park, to explore cooperation with well-known domestic universities and institutes to build innovation and entrepreneurship carrier, collaborative innovation development platform. Has been jointly built the Nanjing University of Technology Engineering Training Center for college students, Xi'an Jiaotong University National University Science and Technology Park Chuzhou Park, Chuzhou Zhongguancun Development Collaborative Innovation Center, Changguang (Chuzhou) high-end equipment research institute, Shanghai University of Engineering and Technology 5G artificial intelligence research institute. Has been approved provincial youth entrepreneurship park, provincial science and technology business incubator, provincial crowdsourcing space, provincial science and technology service industry cluster, provincial small and micro enterprise entrepreneurship and innovation demonstration base, provincial small and medium-sized enterprise public service demonstration platform, provincial sports ecological park and other nine provincial brands.

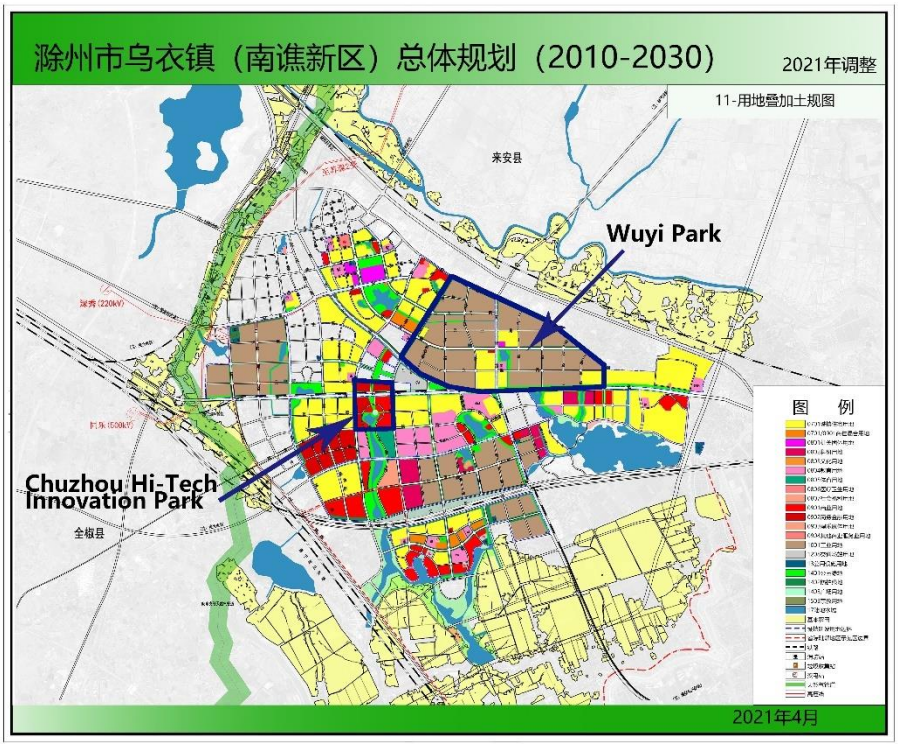

Figure 20 - Location of Wuyi Park and Chuzhou Hi-Tech Innovation Park in Nanqiao new town land use

Source: Elaboration by author with data from Chuzhou Wuyi (Nanqiao new town) Master Plan (2010-2030) (adjusted in 2021)

In the trend of change in industrial upgrading, Nanqiao new town based on the past industrial base, relying on the Wu Yi Industrial Park and Chuzhou Higher Education Science and Innovation City, give full play to the leading role of advanced manufacturing in optimizing the industrial structure. In the economic cooperation with Nanjing as the main city, Nanqiao new town focuses on gradually upgrading the former high-pollution, inefficient heavy industry to high-end manufacturing, supporting advanced equipment manufacturing, new materials, new energy and other industries that already have a certain foundation and advantages to take the lead in the development. At present, Nanqiao new town has formed a certain scale of industrial clusters, attracting local and neighboring labor force to work here.

Chapter 4 Methodology

The subject of this thesis is the underground space development of new cities in China. Nanqiao new town in Anhui Province has been chosen as a case study to explore how to promote the development of new cities through underground space development. The first chapter described the urbanization context of new town development in China, especially the role of government in urbanization and the characteristics of urban transformation in China. Chapter 2 was an overview of new towns in China, describing the legislative process, the role for urban development and the challenges faced by new towns in China. The author concluded the Chapter 2 by introducing the focus of the thesis, which is how to expand the role of new towns through the development of underground space and mitigate the urban problems that arise in new towns.

In Chapter 3, the author presented a basic overview of Nanqiao new town in terms of natural environment, transportation conditions, development history, industrial dependency and future planning. The author chose Nanqiao new town in China as a case study because it is a very worthy project to explore the topic of this thesis. Nanqiao new town is a typical case in the category of new towns that have been upgraded from development zones to integrated cities during the urbanization process in China. This type of new town has the advantages brought by previous development in the transition, but also faces many similar dilemmas.

With the support of policies and driven by the surrounding big cities, Wuyi Town, the foundation of Nanqiao new town, has laid a certain economic foundation through industrialization and has accumulated a lot of population. With the industrial agglomeration and the improvement of supporting infrastructure, Wuyi town and the surrounding area tried to transform from a simple economic development zone into a comprehensive new town. In this process, but also encountered the new town land planning area is too large, ecological environment is destroyed, infrastructure more not on the people's living needs

and other problems. Therefore, Nanqiao new town needs to improve the urban spatial structure in order to solve the current urban problems as soon as possible and make the urban development sustainable. According to the above discussion, the development of underground space can help the new town to improve its predicament. Although Nanqiao new town has started to build underground space, it lacks systematic, orderly and integrated underground space planning. There is a fragmentation, uncertainty and lag between the construction of underground space and the master plan of the new town. The development of urban underground space should be synergistic with the city, or even ahead of time to provide advantages for the development of the city.

Therefore, studying the development of underground space in Nanqiao new town can provide a reference for such Chinese new towns to promote new town development and alleviate urban problems. The development of Nanqiao new town demonstrates the commonality of some new towns in China, so the final research results will be informative and replicable.

In addition, Nanqiao new town also has its own characteristics that deserve additional discussion. As can be seen from the above plan, the development of Nanqiao new town is closely related to the two cities of Chuzhou and Nanjing. On the one hand, Nanqiao new town is going to be the sub-center of its mother city, Chuzhou, and on the other hand, since the neighboring city of Nanjing is developing more rapidly, the development of Nanqiao new town is more likely to be radiated and driven by Nanjing. Nanjing is much more developed than Chuzhou, attracting a large number of foreign workers, but the high price of housing in downtown Nanjing makes many people cannot afford, they will seek to live or buy houses in areas near Nanjing where prices are cheaper, such as Nanqiao new town. In Nanqiao new town and Chuzhou's master plan, Chuzhou hopes to integrate into the Nanjing metropolitan area and develop in tandem with Nanjing. Nanqiao new town, as the closest area to Nanjing in Chuzhou City, is naturally a key area for the Nanjing-Chuzhou urban synergy. If Nanqiao new town is to be better developed, it must strengthen its connectivity

with Nanjing to promote collaboration, and the development of underground space can help in this regard.

Using the underground space of Nanqiao new town as a case study, chapters 5 and 6 of this thesis discussed in particular the scale, location, function and mode of underground space development in the new town. In order to identify the aspects mentioned, a combination of quantitative and qualitative research was used, involving secondary data analysis, field research, and case analysis.

Secondary data analysis and field research were used to analyze the current situation of Nanqiao new town, as this mixed quantitative and qualitative data collection method allowed the author to gain a more comprehensive understanding of Nanqiao new town. Since some of the data collection work was not within the author's expertise and primary data was not available, the author chose to analyze on data provided by relevant professionals and websites. The quantitative study based on secondary data analysis can reflect to a certain extent the current situation of Nanqiao's socio-economic development level, urban master plan, underground space exploitation status, and geographic environment. The data were mainly obtained from government plans, reports, and manuals; and authoritative websites in various specialized fields, such as the National Bureau of Statistics, the China Seismic Activity Fault Detection Data Center, and the Geological Survey of China. These data helped the authors to make the scale prediction and suitability assessment of underground space development in Nanqiao new town. Site research as a qualitative study can complement the status quo information, and the author personally visited the case sites to make direct observations, obtain photos, and record psychological feelings to support the status quo analysis.

In Chapter 5 of the thesis, the author processed and analyzed the collected data by Excel, Arcgis, AutoCAD, and Photoshop to illustrate the current situation of underground space in Nanqiao new town and to forecast the demand and suitability assessment of future underground space development. Rational underground space demand prediction can promote the intensive development of urban space and help to save resources. An accurate

assessment of the suitability of underground space development can help protect the ecological environment of the new city and maintain the ecological balance.

In Chapter 6 of the thesis, the author explored the functions and modes of underground space development in Nanqiao new town through case analysis. The thesis searched for reference concepts in past practical projects and summarized the functional options and development modes of underground space development in Nanqiao new town in the context of the actual situation of Nanqiao new town. Ultimately, the development of underground space would give Nanqiao new town a safe, dynamic and sustainable development environment.

Conclusion, the final part of the thesis, summarizes the general pattern of underground space development in China's new towns, particularly those transformed from development zones into integrated new towns, based on the discussion of underground space development in Nanqiao new town above. Finally, the limitations and challenges of the study were elaborated, and directions for further discussion were suggested.

Chapter 5 Nanqiao new town underground space status, forecast and assessment

Before the study of underground space development in Nanqiao new town was conducted in this thesis, a part of underground space construction had already been carried out in Nanqiao new town, so the analysis for the existing underground space is very necessary. In addition, the prediction of the future underground space scale of Nanqiao new town is to determine the total amount of development so as to avoid overbuilding and wasting manpower, resources and capital. The suitability assessment of underground space in Nanqiao new town is to comprehensively understand the natural environmental background and economic and social context of underground space development. All these work is to lay the foundation for the subsequent determination of the function setting and development mode of underground space.

5.1 Analysis of existing underground spaces in Nanqiao

At present, there are 1.56 million m^2 of underground space in Nanqiao new town, of which 768,576 m^2 (49%) is built and 793,364 m^2 (51%) is under construction. The underground space is mainly distributed in the urban area in the north of Nanqiao new town. There are 40 underground space projects, of which 34 are residential communities, 4 are public service facilities and municipal projects, 1 is a science and innovation industrial park and 1 is a commercial office facility (Figure.21).

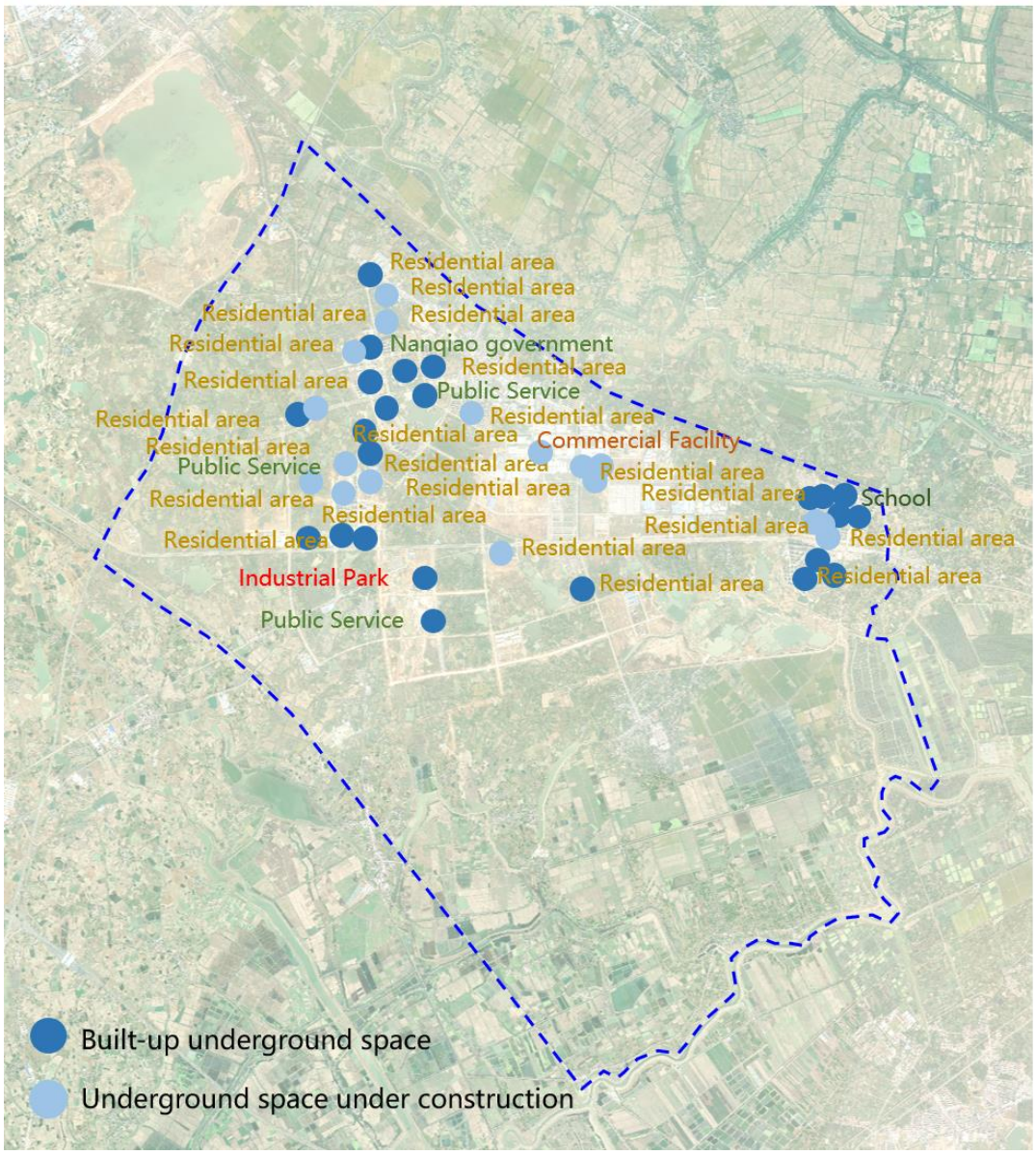

Figure 21 - Distribution of underground space under construction and built in Nanqiao new town

Source: Elaboration by author

These underground spaces have a single function, all underground parking allotment, of which the parking allotment of residential buildings is dominant, with an area of 1.47 million m^2, accounting for 94.14%, the parking allotment of public buildings is less. In addition, the vertical stratification of underground space in Nanqiao new town is simple, and the development depth stays in the shallow layer of the ground. There are 1.48 million

m^2 of underground space developed on the one layer, accounting for 94.79%, and a very small amount of underground development on the two layers, only 81,400 m^2, accounting for 5.21%, with no other deeper development projects.

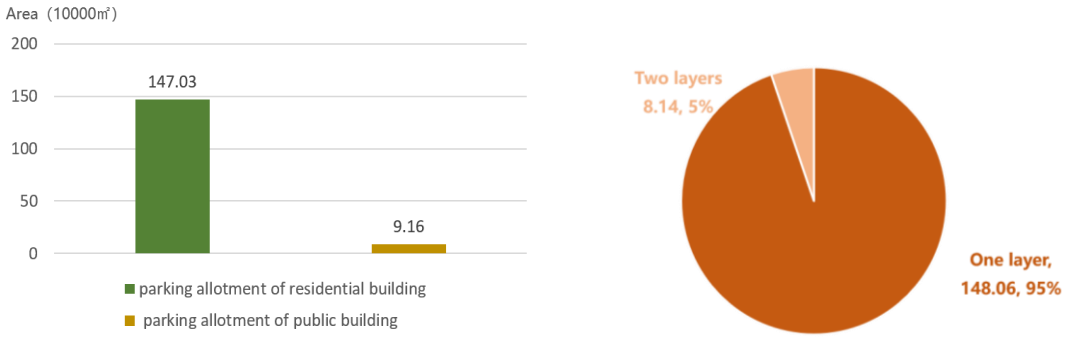

Table 4-5 - Analysis of underground space in Nanqiao new town. On the left: functional composition of underground space. On the right: Vertical stratification of underground space.

Source: Elaboration by author

In a word, the underground space of Nanqiao new town is in the period of initialization of underground space construction. It is mainly built as a single unit, with a single function and small scale, combined with the scattered layout of residential communities and public buildings.

5.2 Forecast of underground space demand

Sustainable use of underground space means using underground space resources in a way that meets the needs of people today without compromising the interests of future generations. However, the development and utilization of underground resources is irreversible, non-renewable and difficult to transform. The development cycle of underground space is long and the investment is large, and it has an important impact on the socio-economic and environmental development of the city after completion.

For a city, too much or too little underground space development is not conducive to the development of the city. The amount of underground space development exceeds the demand of economic development, which will cause waste of resources and is not conducive to the sustainable development of the city; the amount of underground space development is too small and lags behind the economic development, which will increase the compound of urban ground space construction, easily produce traffic congestion, environmental pollution and other problems, and the lack of urban intensification and low operational efficiency. Therefore, it is important to grasp the rule of underground space development and utilization scale, master the method of predicting underground space development scale, and reasonably develop and utilize urban underground space for sustainable urban development.

The underground space prediction of Nanqiao new town is divided into three steps. The first step is to analyze various types of underground space prediction theories and evaluate their advantages and disadvantages; the second step is to determine the prediction method and make predictions in conjunction with the actual situation of Nanqiao new town; the third step is to compare the scale of underground space in other similar cities and new towns for calibration and draw final conclusions.

5.2.1 Underground space scale forecasting methods

According to the urban underground space plan that has been prepared and introduced, different scale and type of cities have different methods of demand forecasting, summarizing the scale of urban underground space forecasting work, there are mainly the following methods for forecasting the scale of urban underground space.

(1) Land use classification forecasting method ("top-down" forecasting)

The land use classification method is based on the classification of urban land above ground to deduce the use and amount of urban underground space. First, the main functions

of the city are divided into several categories, namely residential areas, urban public facilities, urban squares and large green areas, industrial and storage logistics areas, and urban infrastructure systems. Then, based on the judgment that aboveground and underground construction intensities have corresponding trends, the statistical analysis of the aboveground construction volume is used to determine the land value of each area, which in turn guides the distribution of construction intensity of urban underground space. The construction volume of underground space in each area is finally determined, and then aggregated to form the total amount of underground space construction in the study area.

Evaluation: The forecasting method is simple, combining the empirical data of land transportation function demand and the external influence of economic and spatial factors to deduce the intensity of single demand index, which is more in line with the actual muscle of urban land development intensity.

(2) Underground Functional Forecasting ("Bottom-Up" Forecasting)

As the name implies, the functional underground forecasting method is to estimate the future use of underground space directly according to its functional plan. First, the underground space is divided into four major categories based on the main functions of the underground space. Then, the functions are subdivided and detailed on the basis of the major categories. Finally, based on the demand principles of different functional subdivisions of underground space, the demand is forecasted by category and the total demand for underground space in the city is summarized and calculated (Hou, 2013).

Evaluation: Based on the clear classification of urban underground space functions and clear construction standards, this study has the characteristics of realistic data and fitting the demand for urban space use. And it can provide basic support for the determination of the total amount and layout of various types of underground space in the next step.

(3) Construction intensity forecasting method

Different cities have different intensity of underground space development, and different areas of the same city also have different construction intensity. The construction intensity demand forecasting method is to determine the amount of new underground space required at each level through analysis and calculation based on the construction intensity of the ground plan and the socio-economic development level of the city. The factors affecting the intensity and scale of underground space development include: the upper planning, regional population density, regional average GDP, and the floor area ratio of buildings on the ground. When the urban population density and the average ground GDP are at a high level, the urban underground space is suitable for high-intensity and large-scale development (Zeng, 2018).

Evaluation: calculating the demand for underground space development based on the city's current development level and future planning. This method helps different cities to determine a suitable intensity of underground space development and underground space utilization planning according to their own situation and local conditions.

(4) Per capita demand forecasting method

The per capita demand forecasting method calculates the demand for underground space by determining the number of people in the city within the planning horizon and forecasting the future planning period. In addition, the per capita demand for underground space is determined according to the specific conditions of the city. Generally, two indicators are used for analysis and prediction, one is the per capita index of underground space development, and the other is the per capita planning land index. Starting from the per capita index of urban planning, the per capita land use standard is subdivided into several aspects, such as: per capita residential land use, per capita public facilities land use, per capita green area and per capita road square land use, etc., and on this basis, the per capita living and residential land use area is obtained by adding up. In other words, the scale of per capita

land use is calculated based on the overall planning of the city, and the total demand for urban underground space is calculated by combining the planned population scale.

Evaluation: The forecast method based on the city's general plan is simple and easy to use, and the approximate size of underground space required can be obtained.

(5) Comprehensive demand forecasting method

The comprehensive demand forecasting method is mainly to calculate the scale of urban underground space demand from three aspects. The three aspects are mainly: locational demand, systemic demand and facility demand (Xu, 2016). The locational demand is a functional zoning in the urban planning of the area block, such as: the central area of the city, the residential area, the urban renewal area, the square green area, the historical and cultural construction area, the factory industrial area and the storage area. These areas are grouped into several categories and established criteria for analysis and prediction. Systemic demand refers to subsystems that contain various urban systems, mainly infrastructure and public facilities. It includes underground dynamic and static transportation system, logistics system, public facilities system, disaster prevention and mitigation system, and material and energy reserve system.Facility-based demand is the demand for underground space from various facilities that are closely related to people's daily life, mainly various public facilities, such as: financial, commercial, office, medical, sports, recreational, research and education and other large public buildings.

Firstly, under three comprehensive demand analyses, they are divided into categories. Then the urban underground space is sorted out, refined, analyzed and summarized according to the characteristics of each category's demand for underground space. Finally, the total urban underground space demand is calculated by combining various relevant indicators of the overall urban plan.

Evaluation: The forecasting perspective is comprehensive and in-depth, and the results have greater credibility. However, there are overlapping demands in the three

aspects, which may result in redundant and superfluous forecast data. In addition, it is difficult to define various indicators related to urban planning, which is not conducive to later calculations.

(6) Hierarchical analysis forecasting method

The hierarchical analysis forecasting method requires a comprehensive consideration of two factors that affect urban underground space demand: internal influencing factors (factors that directly affect urban underground space demand, such as location, land use nature, and urban functions) and external influencing factors (factors that indirectly affect urban underground space demand, mainly the economic and social development level of the city) (Hou, 2013).

Combined with the overall urban planning layout structure, the influencing factors of underground space demand are processed using exploratory factor analysis, and the main influencing factors that can explain most of the variables are summarized. Then, the urban underground space demand is divided into levels according to land use and demand area, and finally the graded intensity of urban underground space demand is obtained. The amount of underground space is calculated based on the intensity of demand.

Evaluation: The advantage of this method lies in analogy with the experience of similar cities, combining the local location characteristics to make hierarchical forecasts and derive the total urban underground space development scale. However, the construction of the prediction model is subjective and all prediction models must be supported by sufficiently rich indicators of social and economic aspects, which is more difficult to achieve (He, 2018).

5.2.2 Forecasting underground space in Nanqiao new town

Each of the above mentioned six methods for predicting the size of underground space has its own advantages and shortcomings. Based on the data that the authors were

able to collect and the actual situation of Nanqiao new town, this thesis adopted the land classification forecasting method. The flowchart of underground space prediction in Nanqiao new town is shown in Figure 22.

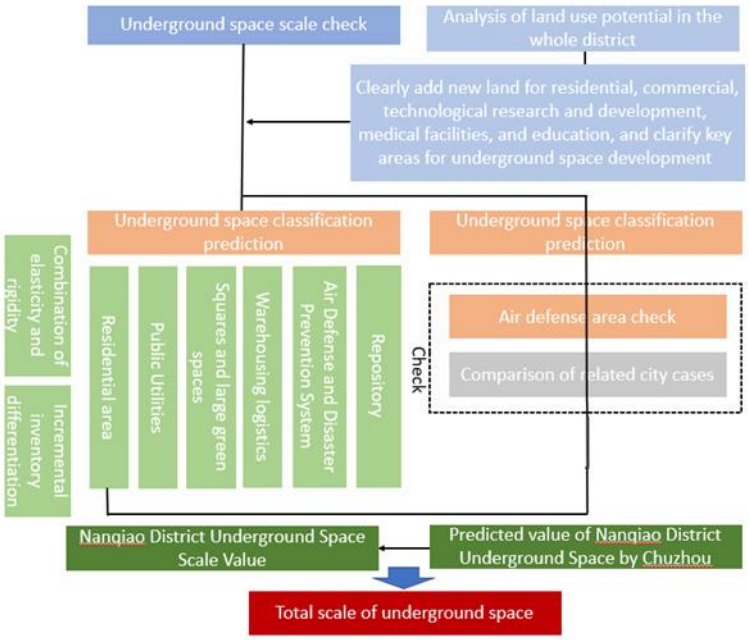

Figure 22 - Flowchart of underground space demand forecasting
Source: Elaboration by author

The first step was to determine the land use potential of the study site according to the upper planning of Nanqiao new town, to clarify the new land use for residential, commercial, technology R&D, medical facilities, education and culture, etc., and to understand the core area of Nanqiao new town development.

The second step was to predict the demand for underground space for each type of use according to the classification of aboveground land. The sites requiring underground space in Nanqiao new town include: residential areas, public facilities, squares and large green areas, industry, warehousing and logistics, underground disaster and air defense facilities and underground storage. In addition, in order to ensure the efficient use of underground resources, the policy of combining the level of warfare is adopted, so the

underground space disaster prevention and air defense facilities and underground storage were included in the predicted scale of the previous items, and the data were not counted in the total amount in the statistics.

Meanwhile, attention was paid to the combination of elastic demand and rigid demand of underground space in this research. The functional uses of underground space were mainly divided into underground parking, underground public building facilities, underground human defense facilities, underground infrastructure and underground storage facilities. The demand for urban underground space arises from a variety of zones and systems, and the purpose of the demand differs for different land nature and different zones, and the content of the demand varies. Among them, the demand for underground space for functions such as allotted parking lots, human defense facilities, subways and municipal pipelines is definite and rigid, while commercial facilities, office facilities and educational facilities do not necessarily need to use underground space to meet such demand, which is potential and flexible, and the feasibility of building underground is only considered under specific conditions. Therefore, the demand for underground space includes definite rigid demand and potential elastic demand. The following was a forecast of the demand for underground space in Nanqiao new town divided into several items, such as residential areas, urban public facilities, squares and green areas, and then illustrated from two aspects, rigid demand and elastic demand.

The third step was to conduct the underground volume ratio calibration, and the main content of this part was compared with other relevant urban underground space cases. After the calibration, the underground space forecast data is the final total amount of underground space expected to be planned in Nanqiao new town. This result avoids the waste of resources to a certain extent and promotes the sustainable development of the city.

According to *"Chuzhou City Territorial Spatial Master Plan (2020-2035)"*, the total area of urban construction land in Nanqiao new town in 2035 is 360,000 square kilometers. Among them: residential land accounts for about 27.28%, land for public administration and public service facilities accounts for about 9.54%, land for commercial service facilities

accounts for about 9.30%, industrial land accounts for about 25.47%, land for roads and traffic facilities accounts for about 13.85%, land for public utilities accounts for about 0.47%, and land for green areas and squares accounts for about 14.09%.

(1) Land classification forecast - Demand for Underground Space in Residential Areas

The underground space under the residential area is mainly for underground parking lot and human defense facilities, so all the underground space in the residential area is rigid demand. The demand for underground space in the residential area of Nanqiao new town was calculated according to the population of the residential area, and the calculation formula was as followed:

$$S = \frac{P}{h} acI$$

S is the total area of underground space in the residential area, P is the planned population, h is the average number of people per household, a is the average number of cars per household, c is the area occupied by each car, and I is the underground parking rate (Table.6).

According to "*The Fourteenth Five-Year Plan for National Economic and Social Development of Nanqiao District, Chuzhou City and the Outline of Vision 2035"*, the population of Nanqiao new town is expected to reach 350,000 in 2035, and the average household population is calculated according to the Chuzhou city statistical caliber of 3.2/household; the average household car ownership and floor space occupied by each car are calculated according to "*Chuzhou City Urban Planning Management Technical Regulations*" for parking indicators and the "*Chuzhou City City General Planning (2012-2030)"* requirements, respectively, the value of 0.4 and 30 square meters; according to the current ratio of above-ground and underground parking spaces in Nanqiao new town District, the underground parking rate is basically between 50%-70%, and is expected to be 80% of the underground parking rate in 2035.

Residential plot name	Aboveground parking space amount	Underground parking space amount	underground parking rate
Dingyuan	110	195	63.9%
Qingliu	288	340	54.1%
Fenghuang	449	475	51.4%
Shiji	300	650	68.4%
Tongxin	108	178	62.2%
Lingxi	186	185	50%

Table 6 - Parking Status of Residential plot in Nanqiao new town

Source: Elaboration by author with data from Nanqiao District Government

Therefore, the underground space under the residence of Nanqiao new town in 2035 is: 350,000/3.2*0.4*30*80%=1.05 million square meters.

(2) Land classification forecast - Urban Plaza and Large Green Space Underground Space Demand

All under urban squares and large green areas are flexible demand. According to "Chuzhou City Territorial Spatial Master Plan (2020-2035)", the total area of planned square green space in Nanqiao new town in 2035, excluding the area of protected green space and prohibited development, is 124.31 hectares.

New town	Tianfu	Jiangbei	Dongbu	Zhendong	Hengqin
Proportion of underground space of urban plaza and large green space	3%	7%	4%	2%	4%

Table 7- Proportion of underground space development of plazas and green areas in different new towns

Source: Elaboration by author with data from underground space planning in multiple new towns

Combined with other new cities' underground space development ratio of plazas and green areas, based on the actual situation of Nanqiao new town, according to the

development and utilization of underground space of 2%-4%, a total of 25,000-62,000 square meters of underground space is needed for urban plazas and large green areas in Nanqiao new town by 2035.

(3) Land classification forecast - underground infrastructure demand

Ning-Chu Express Rail S4 passes through Nanqiao new town and sets up three stations, but it is not clear whether the rail transit is an above-ground or underground line, and can only be realized in the vision, so this did not count in the total forecast.

In addition, parking lots and public parking lots were included in the public facilities and plaza green space, so the forecast was not repeated here.

(4) Land classification forecast - Demand for underground space under urban public facilities

The underground space under urban public facilities includes underground allotted parking, underground commercial street, underground complex, underground office, underground recreation and culture, etc. Among them, underground allotted parking is a rigid demand and underground commercial is a elastic demand, so the total demand for underground space of public facilities was calculated first, and then the rigid demand for underground allotted parking was calculated according to the underground parking rate.

The public facility sites considered for underground space development include administrative office, commercial and financial, cultural and entertainment, sports land, medical and health, and educational and scientific institutions, etc. Therefore, the area of underground public facilities in Nanqiao new town was predicted according to different land use properties. The author measured the underground space scale area of various types of land use in Nanqiao new town in 2035 based on *"Chuzhou City Territorial Space Master Plan (2020-2035)"* respectively. The formula is as follows

$$P = bfL$$

P is the total scale of underground space for public facilities, *b* is the scale of land for construction of public facilities, *f* is the floor area ratio of ground buildings, and *L* is the scale ratio of underground buildings to above-ground buildings. The ground building volume rate was referred to the "Chuzhou City Urban Planning Management Technical Regulations"; the underground to aboveground building ratio *L* for the development of underground space for public buildings was determined with reference to the Nanqiao District to which Nanqiao new town belongs and the development status of other cities.

Taking into account the building standards of other cities and the current situation of underground space construction in Nanqiao District, the ratio of underground and aboveground buildings in Nanqiao new town is 0.04 for administrative offices, 0.03 for education and research, 0.05 for commercial and financial sites, and 0.05 for medical and health sites. Since the current status of Nanqiao new town is small in terms of cultural and recreational land, sports land, social welfare land and cultural relics protection land, the ratio of underground and aboveground buildings in Nanqiao new town was taken with reference to other cities. In other words, the ratio of underground to aboveground buildings for cultural and recreational purposes is 0.04, and the ratio of underground to aboveground buildings for sports purposes is 0.05. So the underground space area of public facilities in Nanqiao new town in 2035 is 561,000 square meters (Table.8).

Public facilities category	**Planned land use in 2035 (10000 ㎡)**	**Volume rate**	**Underground to underground building ratio L**	**Underground building scale (10000 ㎡)**
Administration	26.86	1.8	0.04	1.93
Business finance	424.75	2	0.05	37.33
Culture and entertainment	190.04	1	0.04	7.6
Sports	16.82	0.5	0.05	0.42
Medical hygiene	23.19	1.5	0.05	1.74
Education and Research	468.98	0.5	0.03	7.03

Social Welfare	3.61	0.4	0.05	0.07
Total	1144.25	144.62		

Table 8 - Forecasted area of underground space for public facilities in Nanqiao new town

Source: Elaboration by author

(5) Land classification forecast - Demand for underground space in industrial and storage and logistics areas

The underground space under the industrial and storage and logistics area is basically elastic demand. According to the *"Chuzhou City Territorial Spatial Master Plan (2020-2035)"*, the total area of planned industrial land in Nanqiao new town in 2035, excluding the area prohibited for development, is 1,409.91 hectares.

The total area of planned storage land in Nanqiao new town in 2035, excluding the area prohibited for development, is 64.75 hectares.

New town	Tianfu	Jiangbei	Dongbu	Zhendong	Hengqin
Proportion of underground space for industrial and warehousing logistics	5%	8%	4%	3%	5%

Table 9 - Proportion of underground space for industrial and warehousing logistics in different new towns

Source: Elaboration by author with data from underground space planning in multiple new towns

The proportion of industrial storage underground space development in other new towns is used as a reference, combined with the actual situation of urban development in Nanqiao new town for prediction. The population scale of the industrial area in Nanqiao new town is small, and the demand for underground space is low. Therefore, the ratio of underground space area of industrial land to ground floor area is 0.5%-1%, and the ratio of underground space area of storage land to ground floor area is 2%-4%. Therefore, in 2035, the total demand for underground space in Nanqiao new town Industrial Zone is 70.5-14.10

million square meters; the total demand for underground space in storage area is 13-26 million square meters.

(6) Land classification forecast - Demand for underground air defense and disaster prevention system

The human defense engineering system includes command engineering, medical professional team engineering, air defense professional team engineering, personnel shelter engineering and supporting facilities engineering. The number, type, grade, scale and layout of these facilities were determined based on the *"Tactical Technical Requirements for People's Air Defense Projects"* and the *"Chuzhou City Wuyi Town (Nanqiao new town) Master Plan (2010-2030)"*. The total demand for human defense projects in Nanqiao new town was expected to scale 50.8 million square meters. Due to the implementation of the integrated planning strategy of combining peace and warfare, this data was included in the previous underground space projection scale and would not be calculated additionally.

(7) Land classification forecast - underground storage demand

To strengthen urban security, it can be considered that various types of underground storage should be built in the deep underground space of -50~-100m, including hot water storage, cold water storage, compressed air storage, liquefied natural gas storage, fuel storage, dangerous goods storage, etc. The scale of these reservoirs would be determined at the time of engineering design. In the planning stage, the total scale of Nanqiao new town was expected to be no less than 200,000 cubic meters. Since the scale of comprehensive pipe corridor, underground storage, etc. is measured in volume, such underground space was not included in the construction total in other types of forecasting methods.

(8) Total underground space forecast

Aboveground land use	Rigidity /Elasticity	Corresponding underground space type		Demand(10000 ㎡)	Remark
Residential area	Rigidity	Parking lot		105.0	
Public facilities	Rigidity	Parking lot		56.1	
Squares and large green spaces	Elasticity	/		2.5-6.2	
Industrial area	Elasticity	/		7.1-14.1	
Logistics storage area	Elasticity	/		1.3-2.6	
	Rigidity	Infrastructure	Equipped with parking lot	/	Has been included in utilities
	Elasticity		Public parking lot	/	Has been included in the square green space
	Elasticity		Rail	/	Long-term consideration
	Elasticity		Underground road traffic	/	To be determined
	Rigidity		Underground municipal facilities	/	
	Rigidity	Air defense and disaster prevention		6.9	Combination of peace and war
	Elasticity	Underground storage		/	
	Rigidity	168 (10000 ㎡)			
	Elasticity	10.9-22.9 (10000 ㎡)			
Total		178.9-190.9 (10000 ㎡)			

Table 10 - Nanqiao new town total underground space forecast

Source: Elaboration by author

By 2035, the total rigid demand for underground space in Nanqiao new town is 1.68 million square meters, and the elastic demand is 109,000-229,000 square meters, for a total demand of 1.789-1.909 million square meters.

5.2.3 Calibration and Conclusion

When calibrating the predicted value of underground space demand, analogies can be made to the underground space demand of cities with similar levels of development and positioning (Shao, 2021), drawing on the forecasting experience of other cities. The forecasted scale of underground space in Nanqiao new town was calibrated by analogous analysis of the per capita underground space development scale in some cities, so as to understand the level and scale of urban underground space development and utilization in Nanqiao new town in the future (Table. 11).

Comparing cities with similar per capita GDP and new cities with similar development orientation, it could be seen that the planned per capita underground space development scale of these cities and new cities is concentrated in the range of 4.8-6.1 m2/person. The per capita underground space development scale of Nanqiao new town is 5.1-5.5 m2/person, which is within the above-mentioned range.

City/New town	2035 planned population size (10,000 people)	2035 planned underground space development scale (10,000 ㎡)	2035 Planning underground space development scale per capita (sqm/person)
Xuzhou	715	5000	7
Huaian	410	2000	4.9
Taizhou	277	1400	5.1
Yancheng	503	3100	6.2
Tianfu	500	2700-3000	5.5-6
Dongbu	160	720	4.8
Hengqin	65	400	6.2
Zhengdong	70	480	6.9
Jurong	40	207-268	5.1-6.7
Nanqiao	35	179-191	5.1-5.5

Table 11- Planning of underground space development in different cities/new towns
Source: Elaboration by author with data from underground space planning in multiple cities and new towns

5.3 Underground space suitability assessment

The resource and environmental assessment of Nanqiao new town was conducted to examine the suitability of developing underground space in the area. In this study, the natural environment and socio-economic conditions of Nanqiao new town were evaluated and analyzed separately according to the weight of influence of each type of factor, and finally the results of both were considered together to propose the regional location for the development of underground space in Nanqiao new town.

5.3.1 Assessment Methodology

Underground space resources and environmental assessment can provide a full understanding of the underground space resources of a city. After recognizing the strengths and weaknesses of underground resources and the surrounding environment, the planning and design can effectively promote the sustainable use of underground space. According to the development and utilization plan of Nanqiao new town and local geological factors, the scope of this assessment included shallow spaces in the depth range of 0∼-10m and sub-shallow spaces in the depth range of -10∼-30m. For the space use domain with depth in the range of -30∼-50m and above 50m, the deeper space domain would not be analyzed and studied because the planning of Nanqiao new town rarely involved.

The assessment of urban underground space resources and environment is an interdisciplinary and comprehensive project, which not only involves urban, planning and landscape but also requires many engineering, hydrogeological, natural and human related expertise. For the overall problem composed of complex factors, it needs to be decomposed and reconstructed hierarchically to establish a multi-objective comprehensive assessment index system and model. They are used to guide and standardize the content and process of subsurface space resources assessment, which leads to quantitative description (Shao, 2021). Therefore, after this evaluation referred to various types of underground space

assessment studies, the total order of weights of each evaluation index was determined, and the total order of weights for different depth levels was determined by combining the establishment of index systems at different depth levels. Finally, the evaluation results were quantified and visualized by using Arcgis.

In order to more comprehensively and truly reflect the extent to which urban underground space can be exploited, the selection of urban underground space resources evaluation index should be based on geological, hydrological, ground construction status, socio-economic and environmental factors, from which one or several typical factors are selected instead of the index. Considering the demand and development law of urban underground space development and utilization, the factors could be summarized as natural factors related to underground space resource assessment such as topography, soil and rock, geological disaster, ecologically sensitive area and underground water., and socio-economic aspects such as traffic condition, urban function and population pressure (Figure.22). The assessment results were quantified into five grades of 1, 2, 3, 4, and 5, corresponding to unsuitable, less suitable, generally suitable, more suitable, and very suitable in order.

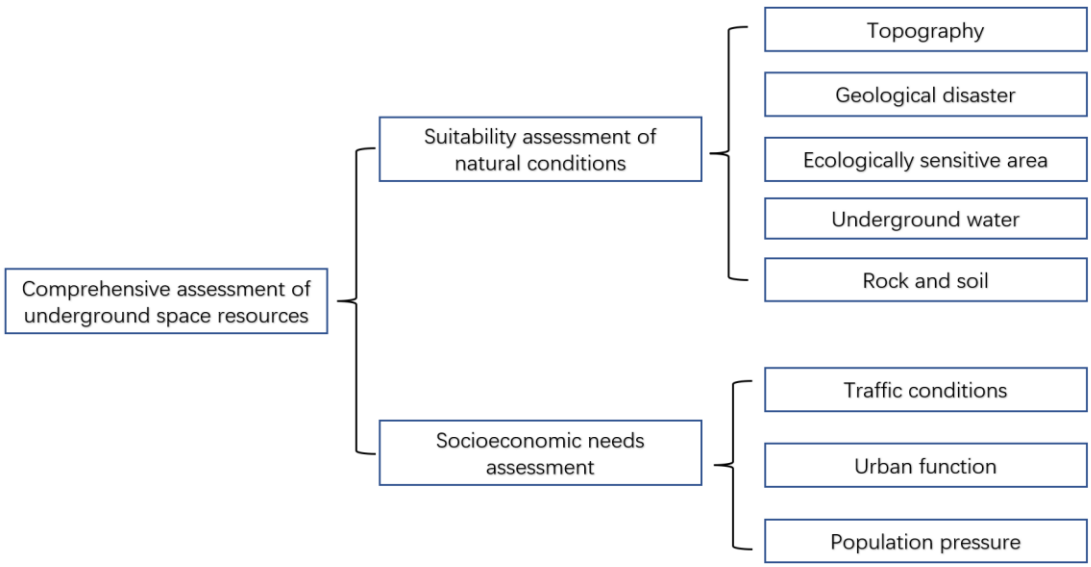

Figure 23 - Comprehensive assessment system on underground space resources

Source: Elaboration by author

The mathematical expressions of the assessment model are as follows.

(1) Suitability assessment model for natural conditions of underground space.

$$I_1 = \sum_{i=1}^{n} a_i w_i$$

I1 is the assessment value of resource engineering suitability, *ai* is the score of each factor, and *wi* is the weight of each factor.

(2) Socio-economic demand assessment model for underground space resources.

$$I_2 = \sum_{i=1}^{n} b_i w_i$$

I2 is the assessment value of the potential demand of resources, *bi* is the score of each factor, and *wi* is the weight of each factor.

(3) Comprehensive quality assessment model of underground space resources.

$$I = w_1 I_1 + w_2 I_2$$

I is the comprehensive quality assessment value of underground space resources, *I1* and *I2* are the engineering suitability assessment value and potential demand assessment value respectively, *w1* and *w2* are the corresponding weights.

5.3.2 Natural environment assessment of underground space

The weights of various natural environment indicators affecting the construction of underground space are listed in the following table (Table.12).

Indicator type	Index	Evaluation Criteria and Qualitative Description				
		5	4	3	2	1
Topography	Slope/(°)	<5	(5,10]	(10,20]	(20,30]	>30
	Relative height difference/m	<5	(5,15]	(15,25]	(25,50]	>50
Rock and soil	Bearing capacity/kPa	>300	(200,300]	(150,200]	(100,150]	≤100
	Cohesion/kPa	>50	(30,50]	(20,30]	(10,20]	≤10
	Internal friction angle/(°)	>40	(30,40]	(20,30]	(10,20]	≤10
Groundwater	Single well water inflow	≤100	(100,400]	(400,700]	(700,1 000]	>1 000
	Groundwater Corrosive	none	slight	generally	severe	very severe
Geological disaster	Disaster susceptibility	none	slight	generally	severe	very severe
	Fault zone influence	none	slight	generally	severe	very severe
ecological sensitivity	Land cover	Fully developed		Not fully developed		difficult to develop

Summary of evaluation criteria for natural conditions on underground space resources(0 ~ - 10m)

Primary indicator	Primary weights	Secondary indicators	Secondary weights
Topography	0.1	Slope/(°)	0.5
		Relative height difference/m	0.5
Rock and soil	0.25	Bearing capacity/kPa	0.33
		Cohesion/kPa	0.33
		Internal friction angle/(°)	0.33
Groundwater	0.2	Single well water inflow	0.65
		Groundwater Corrosive	0.35
Geological disaster	0.25	Disaster susceptibility	0.8
		Fault zone influence	0.2
Ecological sensitivity	0.2	Land cover	1

Summary of evaluation criteria for natural conditions on underground space resources(- 10 ~ - 30m)

Primary indicator	Primary weights	Secondary indicators	Secondary weights
Rock and soil	0.35	Bearing capacity/kPa	0.33
		Cohesion/kPa	0.33
		Internal friction angle/(°)	0.33
Groundwater	0.25	Single well water inflow	0.65
		Groundwater Corrosive	0.35
Geological disaster	0.25	Disaster susceptibility	0.8
		Fault zone influence	0.2
Ecological sensitivity	0.15	Land cover	1

Table 12- Summary of evaluation criteria for natural conditions on underground space resources

Source: Wu, X. Z. 2021. Study on Assessment of Urban Underground Space resources in Wuhu City.

The depth of underground space utilization also affects the evaluation criteria of underground resources. For example, for the development of underground space from 0 to -10 m depth, the state of topography and geomorphology of the surface has an important influence on it; however, for underground space from -10 to -30 m, whatever the state of topography and geomorphology is, it does not have much influence on its development (Gui, 2020).

This evaluation used ArcGIS platform to visualize data related to topography, rocks and soils, groundwater, geological disasters, and ecological sensitivity to form a layer of evaluation elements. Then spatial overlay, analysis and statistics were performed, and each unit was evaluated according to the factor weighting system that had been calculated. Finally, according to different depth development levels, a comprehensive evaluation of the suitability of natural conditions of underground space resources was formed, as shown in Figure.24

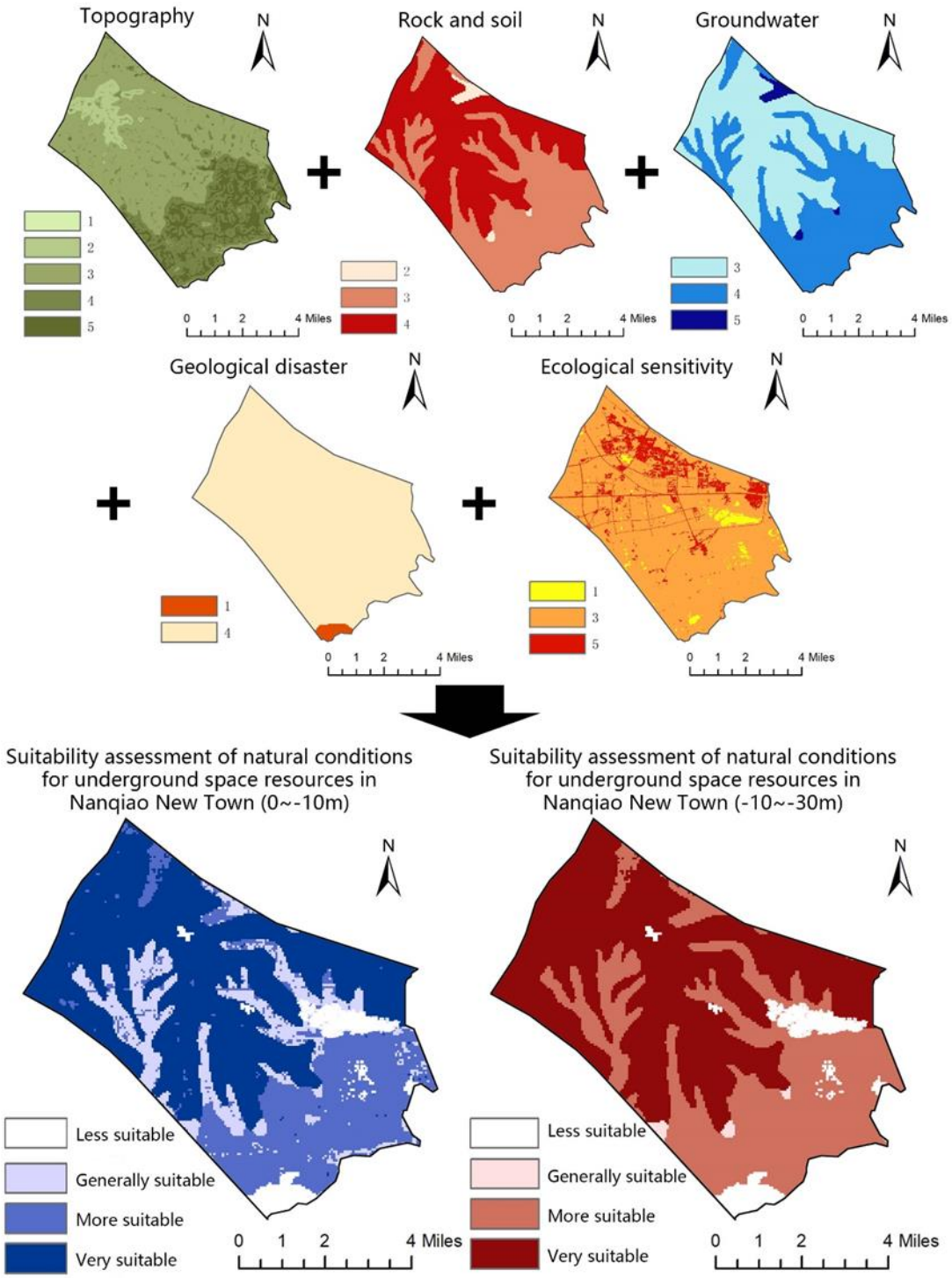

Figure 24 - Comprehensive evaluation of the suitability of natural conditions of underground space resources in Nanqiao new town

Source: Elaboration by author with data from Seismic Active Fault Exploration Data Center, Nanqiao District Government, GeoCloud and National Bureau of Statistics of China

(1) Topography

Nanqiao new town and its surrounding area are mixed terrains consisting of the Qingliu River floodplain, terraces, the inter-river block of Qingliu River and its tributary Xiaosha River hilly undulating land, residual hills and low hills. It is located on the rocks and terraces of the lower Qingliu River. The plain in front of the mountain is cut by erosion and layer erosion to form residual hills and undulating land. The scouring and re-deposition of seasonal floods include the valley of the Qingliu River and the rambling plains. According to the analysis of slope and height difference, it can be seen that the topography of Nanqiao new town is gradually gentle from northwest to southeast. The northwestern part is a slightly undulating plain, while the southeastern part is a more gentle plain.

(2) Geological Disasters

The judgment of adverse geological conditions is mainly related to two indicators: the influence of earthquake fault zones and the susceptibility to geological hazards.

The results of the China Seismic Activity Fault Detection Data Center and "*China Earthquake Parameter Zoning Map (GB18306-2015)* "show no Holocene, Late Pleistocene, Early Middle and Late Pleistocene or Pre-Fourth Set earthquake fault zones in the area of Nanqiao new town. The peak acceleration of ground shaking in Nanqiao new town is 0.05 (g), and the characteristic period of earth-shaking acceleration response spectrum:0.4 (s). According to the *"Seismic Design Planning for Buildings (GB50011-2010)"*, the seismic hazard of Nanqiao new town is at low risk, and the score of this assessment is (4/5).

According to the resource assessment provided by Nanqiao District Government, since 1990, heavy precipitation in Nanqiao new town during the flood season can induce the

Chu River to collapse its banks, which can adversely affect the development of underground space. Due to sand mining activities, Qingliu River, Chu River, some sections of the river within a dozen years back tens of meters, resulting in riverbank failure with long-term and recurrent. Sand mining activities have now ceased, the riverbank gradually stabilized.

(3) Ecologically sensitive areas

Underground space development can reduce the damage to surface vegetation and the occupation of arable land through the use of geotechnical space, but the development should also pay attention to the impact of engineering activities on ecological conditions. In this study, ecological sensitivity was used as an indicator to reflect the sensitivity of ecological environment to the response of underground space development activities, i.e., the protection should be increased in regions with high sensitivity, while the development intensity should be appropriately reduced. Based on the type of surface coverage, the author divided the underground space development zones in Nanqiao new town, which were mainly divided into three types of areas: difficult development zone, non-sufficient development zone and sufficient development zone (Table.13).

Development level	Type of surface coverage	Scoring (out of 5 points)
Difficult development zone	Surface waters, wetlands	1
Non-sufficient development zone	Woodland, shrub, grassland, cropland, bare/sparse vegetated land	3
Sufficient development zone	Building	5

Table 13 - Division of ecologically sensitive areas in Nanqiao new town
Source: Elaboration by author

(4) Underground water

Various underground projects are not only affected by groundwater during construction (e.g., tunnel boring and pit excavation, which is prone to engineering problems such as sand flow, place collapse, landslide and sudden surge at the bottom of the pit), but also will face threats such as uplift and leakage for a long time after completion. The corrosiveness of groundwater the degree of water-richness is one of the essential indicators to judge whether the area is suitable for developing underground space (Wu, 2012).

Nanqiao new town is located in the middle and lower reaches of the Yangtze River, and the Chu River in the southeast divides Nanqiao new town from Nanjing. There are many small lakes on the region's surface, and the Qingliu River extends from south to north. According to the China Geological Bureau, the groundwater in Nanqiao new town originates from the Yangtze River, so the groundwater is freshwater with a mineralization degree of less than 1 (g/L). Therefore, the corrosiveness of groundwater is very low, and the score of this assessment is (5/5). Besides, the water-rich degree of groundwater in the geotechnical body is directly related to underground space development. The maintenance cost after the project is completed; the lower the water-rich amount, the more suitable for development. The water-bearing rock groups in Nanqiao new town are loose rock void water-bearing rock groups and clastic rock water-bearing rock groups, whose water-richness is extremely weak and weak, respectively, which are more favorable for the development of underground space.

(5) Rocks and Soils

Nanqiao new town mainly contains clayey soil, sandy mixed soil type soil (Cs+Ss), clayey soil type soil (Cs) and a minimal amount of complicated - more complex - thickly laminated clastic rock group (Ca). The clayey soils with the single-layer structure are distributed in the southeastern corrugated plain area. Quaternary Pleistocene (Qp) clayey soils with loose - slightly dense structure, plasticity index 10-30, and ferromanganese nodules. The characteristic values of bearing capacity of clayey soils are 240-500KPa, and

the free expansion rate is generally between 40-60%, with weak expansion potential. The internal friction angle of clayey soils is around 20°, and the cohesive force is above 20. The clayey soil and sandy soil multilayer structure class soil is distributed northwest Nanqiao new town, Quaternary Holocene (Qh) clayey soil, sandy gravel, and powder-fine sand. The internal friction of this mixed soil is about 30°, and the cohesion is less than 20. Between the clayey soil, sandy soil multi-structure soil and clayey soil, there is also a small amount of complex and complicated medium-thick laminated carbonate rock group. Due to the repeated tectonic movements of the rock formation, it has reduced mechanical strength of the surface layer and weathered and broken. The compressive strength of this rock group is 45.1-171.4MPa, and the softening coefficient is 0.52-0.9. It is prone to geological disasters such as collapse, landslide, and soil erosion and is very unsuitable for underground space construction.

In general, according to the five indicators selected in this natural resources assessment, Nanqiao new town has the natural environment conditions for developing underground space. Most of the areas in the planning area are favorable for the construction of underground space, except for the surface water sources and areas with a high risk of geological hazards. The northern and the northwestern regions of Nanqiao new town have the highest suitability for constructing underground space with a depth of 0~-10 meters or underground space with a depth of -10~-30 meters. The southeastern part of Nanqiao new town is also highly suitable for natural conditions, where the flat topography and unique groundwater environment can reduce underground space development.

5.3.3 Socio-economic analysis of underground space

For different geographic locations in cities, the value and comprehensive benefits generated by underground space resources are different, i.e., there is significant spatial differentiation in the potential demand for underground space resources. These differences are closely related to socio-economic factors such as traffic conditions, urban functions, and

population pressure in different spaces of the city (Jia, 2008). These factors were also used in this study as important assessment indicators affecting the demand for underground space resources development in Nanqiao new town (Table.14).

Indicator type	Index	Evaluation Criteria and Qualitative Description				
		5	4	3	2	1
Traffic conditions	Rail transit	Level 1 transfer station and subway hub	Ordinary subway station and level 2 transfer station	General bus station and subway line	Main road	Other areas
Urban function	Land use	Business & Finance Cultural Entertainment	Research & Education Public facilities Large residential area Administration	Square & Green space Small and medium-sized residential areas	Industry Warehousing Utilities	Water area Mountain Farmland
Population pressure	Population density (people/km²)	439-860	231-439	103-230	29-102	0-28

Summary of evaluation criteria for development demand on underground space resources

Indicator	Weights
Population pressure	0.2
Transportation conditions	0.45
Urabn function	0.35

Table 14 - Summary of evaluation criteria for Socio-economic demand on underground space resources

Source: Wu, W. B. 2012. Research on the evaluation of urban underground space resources in Suzhou

After collecting the data related to population, traffic and urban land use, based on the set evaluation levels and weights, the author used Arcgis, Photoshop, AutoCAD and other software to process and finally formed the socio-economic demand assessment of the underground space of Nanqiao new town, as shown in Figure.25

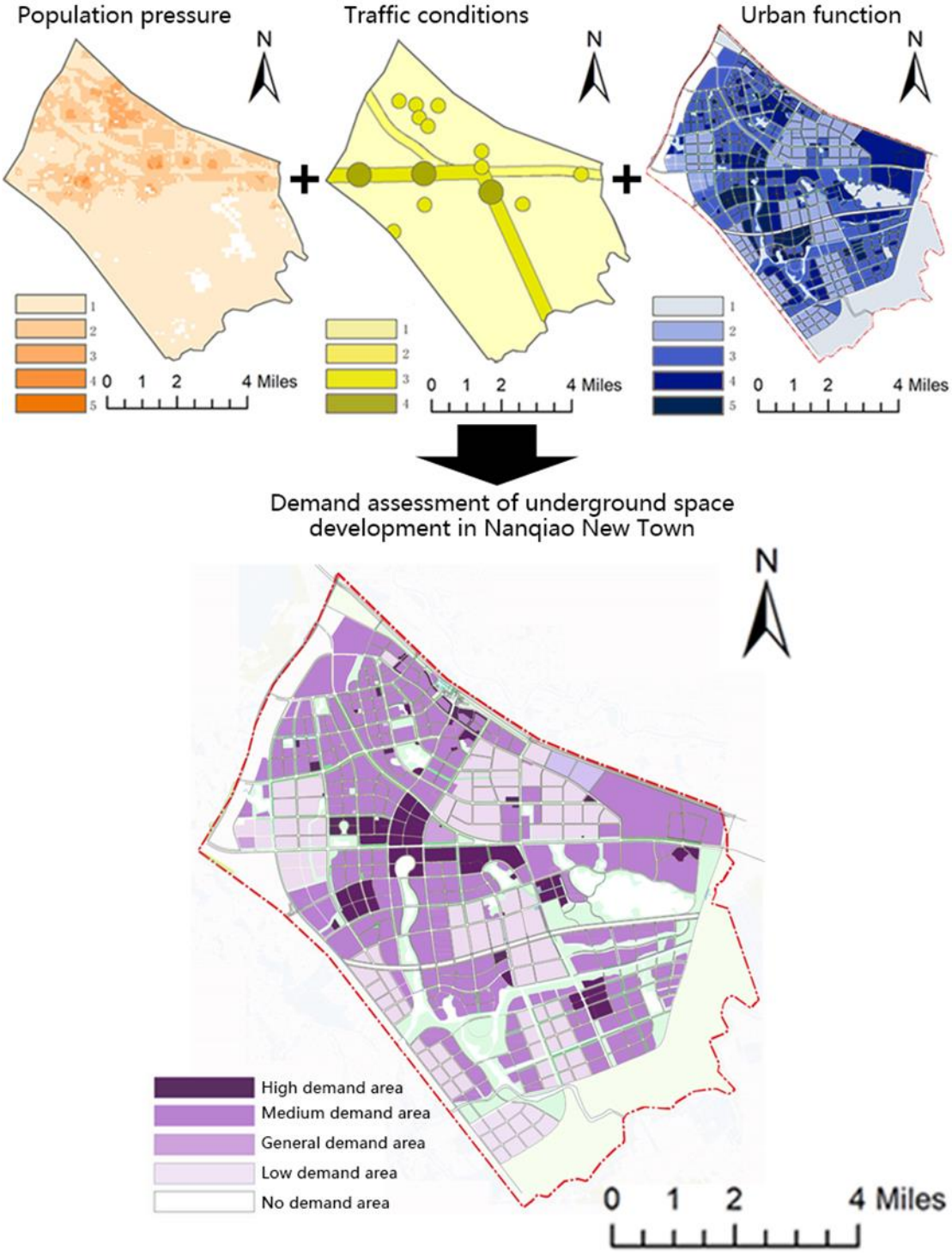

Figure 25 - Comprehensive evaluation of the socio-economic demand of underground space resources in Nanqiao new town

Source: Elaboration by author with data from Nanqiao District Government and National Bureau of Statistics of China

(1) Population pressure

The overall size, density of distribution and composition of the urban population have an essential impact on the demand, spatial utilization patterns and effects of urban resources. Population density is a crucial indicator of comprehensively characterizing the tension of urban space and other resources. The magnitude of population density reflects the number of space resources, transportation resources and municipal facilities per capita occupied per land area in cities. Also, it determines the intensity of demand for conducting condition improvement (Zhou, 2020). Demand is the fundamental driving force to promote the development of underground resources, so the demand for underground space is high in areas with high population density. Underground space development is not advocated in areas with low population density.

Because the scale and development orientation of cities are different, the level of population pressure will be positioned differently. Therefore, this population pressure interval was divided according to the actual situation of population in Nanqiao new town. The high-density population area of Nanqiao new town is mainly located north of Hongwu Road, especially in some large residential areas and commercial office areas. The construction of the new city has taken shape here, so it has attracted a lot of population. Many higher-density residential areas mean a massive demand for underground parking. On the contrary, except for the science and education center and some residential areas south of Hongwu Road, the population density is very low, which is related to its urban construction is not yet perfect. So for the area south of Hongwu Road, underground space planning also needs to be based on the *"Chuzhou Wuyi Town (Nanqiao new town) Master Plan (2010-2030)"* in the positioning of its urban functions.

(2) Traffic conditions

Transportation is the most active element of urban function. Compared with surface transportation, the underground transportation system is more punctual, efficient, and convenient and can reduce harmful gas emissions and noise pollution, which is a necessary means for sustainable urban development. The standard underground transportation system is mainly rail transit, but different types of rail transit stations radiate other impact areas and different development values (Hu, 2020). In many TOD projects in developed countries such as Japan, France, and Canada, underground passages, underground commercial streets, underground pedestrian walkways, underground casinos, and subway station malls have flourished in combination with rail transit construction. Many examples have proved that the area along the subway and around the subway stations is the most potential and valuable place for underground space development.

The attractiveness of urban transportation nodes for underground space development is mainly manifested in two aspects. One is to promote underground space. For example, underground space development near subway stations is easily connected to the subway stations and surrounding buildings, which improves the accessibility and use-value of underground space. The second is the role of rapid convergence and dispersal of pedestrian flow. The development of underground space around traffic nodes is equivalent to expanding the radius and axis of the node's fulcrum of traffic and pedestrian flow organization, promoting urban activities and improving urban vitality (Wu, 2012).

Because of the future construction of Chu-Ning express rail line S4, so located in the territory of Nanqiao new town, the three subway stations (Yuanshan Park Station, Science and Technology City Station and Huangwe Road Station) and along the track are the critical areas for the development of underground space.

(3) Urban Functions

Different functions of the city have different needs for underground space development, which also determines the comprehensive benefits of underground space

development. Usually, the demand for underground space is higher for commercial, transportation and recreational facilities. In cities where motor vehicles are more popular, building underground garages under residential areas is necessary.

According to the latest planning of Nanqiao new town, the south of Hongwu Road will be the focus of the future development of the new town. There are many commercial and financial sites, technology R&D centers, and cultural and entertainment areas planned along the Qingliu River, and the underground space of these sites has high development value. The scattered large and small parks and green areas in the new city are also suitable for developing underground space, which is conducive to creating a healthy and livable urban space. In addition, farmland, natural lakes and rivers are still protected spaces in the plan, which do not require underground space development to avoid damage to the ecological environment.

All in all, within the planning area of Nanqiao new town, the Chu-Ning Express Rail Line S4 Station, Huangxu Road Station and the Science and Technology Park along the line, and the commercial and recreational center are the high demand areas for underground space development. The more densely populated residential areas, public facilities, and planned commercial streets along the river also have medium demand for underground space. Industrial parks, storage land, and green park spaces can be built with appropriate underground space.

5.3.4 Summary

According to the assessment of the suitability of underground space development in Nanqiao new town and the analysis of socio-economic needs, a comprehensive quality assessment of underground space resources is conducted, and the weights are set as shown in the table. The development of shallow and sub-shallow underground space is mainly occupied facilities such as living, commercial, office and transportation, which has a higher weight of potential demand and a lower weight of development suitability (Table.15).

Finally, the underground space of Nanqiao new town was divided into key construction area, suitable construction area, restricted construction area and prohibited construction area (Figure.26).

Indicators	0~-10m	-10m~-30m
Development suitability	0.2	0.3
Socioeconomic needs	0.8	0.7

Table 15 - Comprehensive quality weighting table of underground space resources in Nanqiao new town

Source: Wu, W. B. 2012. Research on the evaluation of urban underground space resources in Suzhou

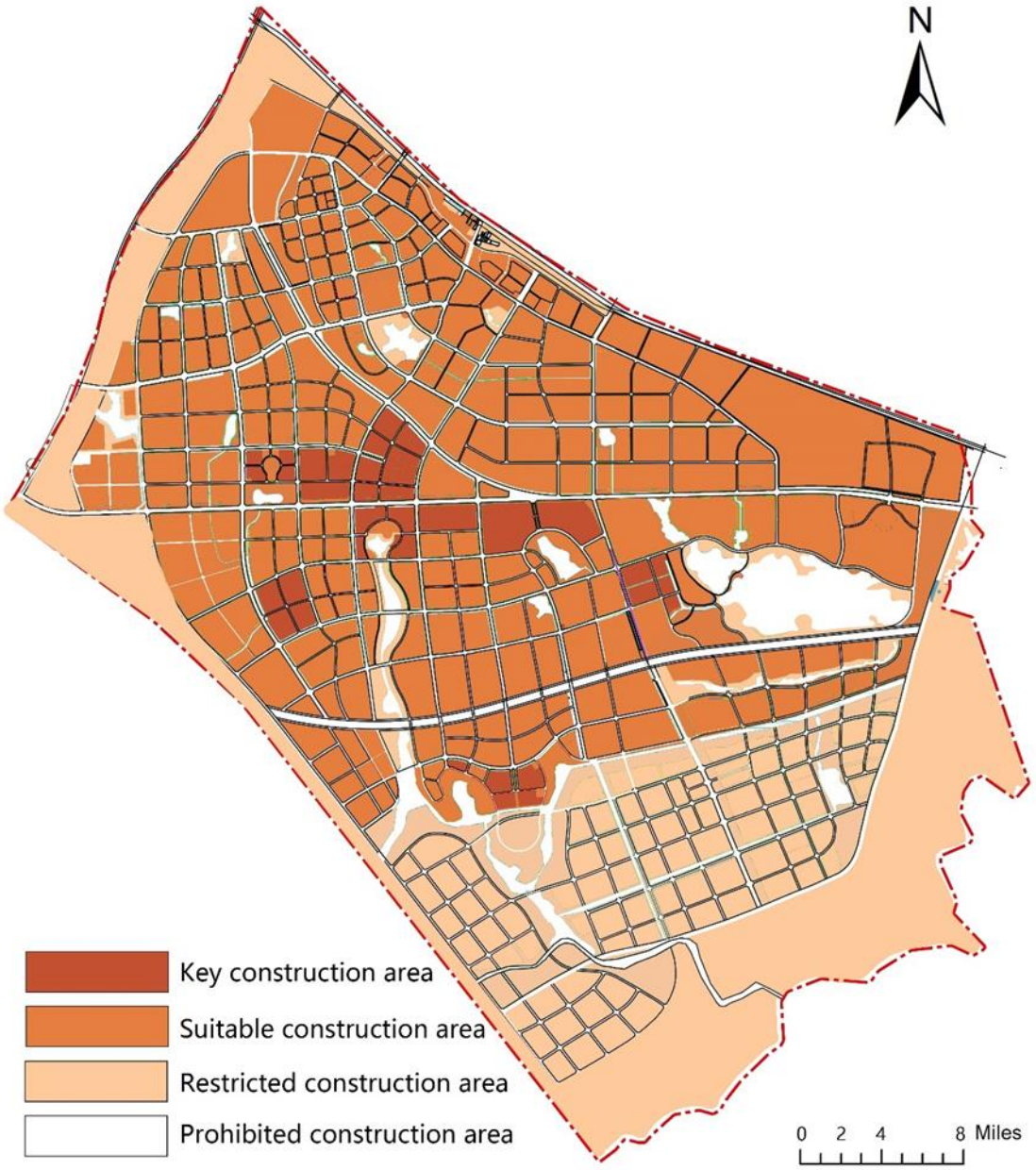

Figure 26 - Layout Plan of underground space in Nanqiao new town

Source: Elaboration by author

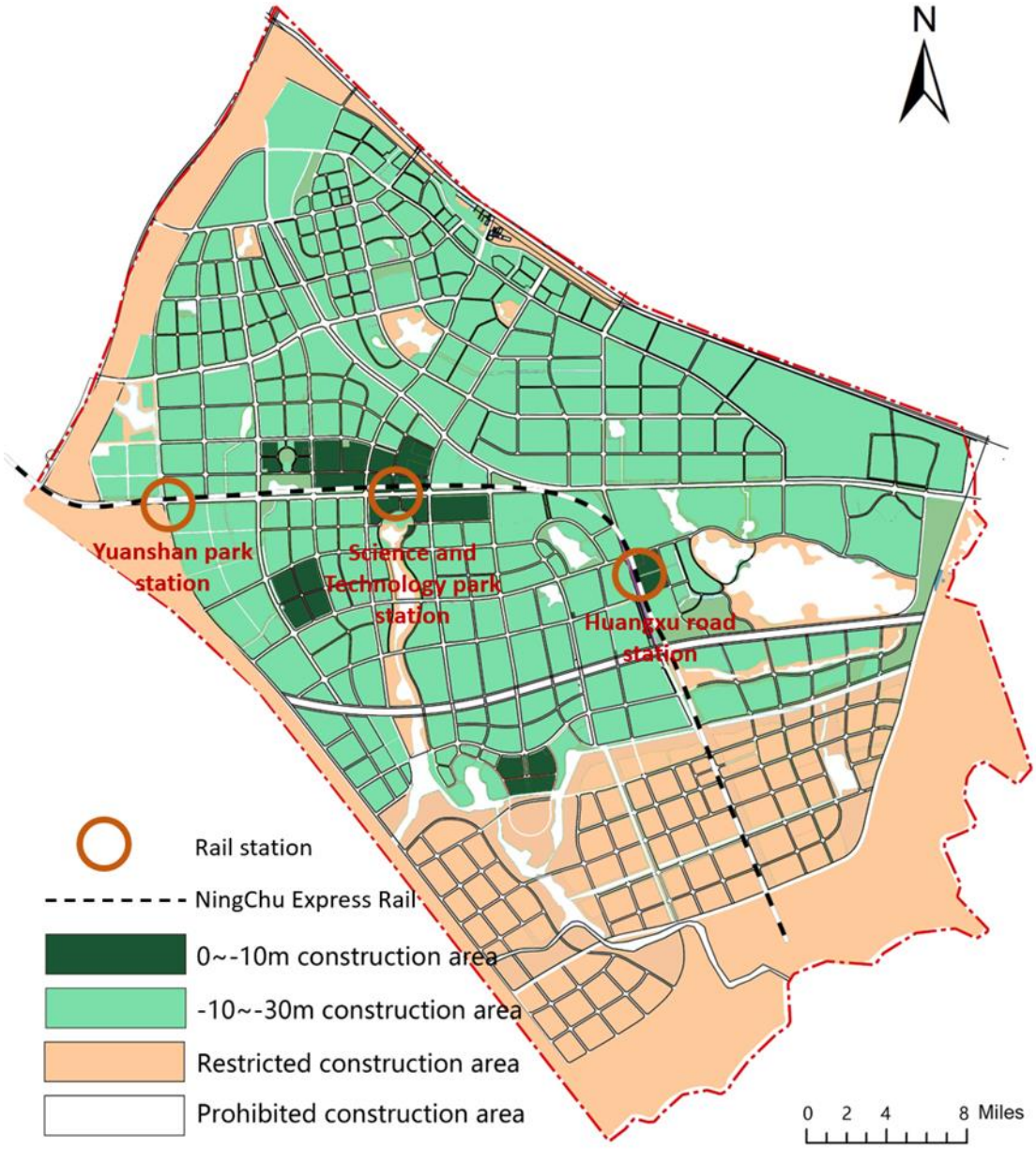

Figure 27- Vertical layout plan of underground space in Nanqiao new town

Source: Elaboration by author

The key construction areas for the underground space of Nanqiao new town are the Chuning Express Railway's Kechuangcheng Station and Huangxu Road Station and their surrounding areas, and the two future commercial and entertainment centers. The underground space in these areas has great potential, so developing -10~-30m depth is recommended. Natural lakes and rivers are prohibited areas for construction as protected

areas. Agricultural land and industrial warehouses are restricted areas, where a small amount of underground space with necessary functions such as human defense and storage can be built. The rest of the large urban areas are suitable for underground space construction, which can be developed according to the demand of urban life of the residents in the appropriate amount of underground shallow space resources (Figure.27).

Chapter 6 Nanqiao new town underground space development strategy

In the development of underground space in Nanqiao new town, four aspects were considered: underground space development in the core area of the new town, multi-functional underground space development in the new town, underground space development in the new town to reduce environmental damage, and underground space connection development in the new town. The urban core is the artery of urban development, where the underground space structure is the most complex and requires many functions. Excellent underground space development in the core area can be a catalyst for the future development of new towns. Multifunctional development of underground space can effectively save resources and create a safe and stable environment for new town development. The development of a new town means the disappearance of part of the natural landscape and farmland. Through underground space development, the damage to the surface landscape caused by surface construction is reduced, which in turn reduces the impact of human activities on the ecosystem and ultimately promotes the sustainable development of the new town. The underground space connectivity project is related to the future development process of the underground space of the new town, and should be fully prepared in the early planning.

6.1 Nanqiao new town core area underground space development

The urban core is the most concentrated area of political, economic, cultural and other public activities in a city, and is the main part of the urban public activity system. Urban core areas are characterized by high accessibility and limited land scarcity. The core areas

of single-core cities are generally located in the geographic center of the city or somehow related to the birthplace of the city, while the core areas of multi-core cities are related to the development of the city's regional economy. For example, the core area of Nanjing is the Xinjiekou shopping district, while the core area of Shanghai includes several areas such as People's Square, Jing'an Temple, Nanjing East Road, and Xujiahui. The core area of the city has a concentrated building layout, saturated ground space, highly dense public activities, and higher development and construction needs than other areas of the city. Urban core areas include business office areas, commercial center areas, cultural and sports center areas, transportation hub areas and so on, which play an important role in the development of the city. It has good social service and urban landscape, and carries more important urban functions.

In the development process of some large cities and mega-cities, due to the saturation of land development in the urban core and high rents, urban planners choose to separate some important functions of the city and gradually form urban sub-centers at the edge of the mother city to promote one or several urban functions to play their full role. In China, there are many such new towns created as a result of the development of urban sub-centers, such as new research towns, new political towns, new economic development zones, new business towns, and so on. New towns are established in the urban periphery or in the combination of urban and rural areas, and although they have more space for development than their parent cities, they should also be developed intensively in their urban cores in order to ensure sustainable urban growth. In addition, the core area is related to the future development status of the new towns, some of which are currently stagnant due to lack of vitality in China. Underground space development in the core area can enhance the attractiveness of the new towns, which should always be vibrant and provide a constant impetus for the sustainable development of the new towns.

Therefore, underground space development in the core area of a new town is the primary key.

The underground space development in the core area of the new town includes

three main aspects: integrating aboveground space and underground space to achieve complementary functions; using transportation catalysts to stimulate underground space and promote the construction of supporting living facilities; and realizing a three-dimensional pedestrian system to improve accessibility.

6.1.1 Integration of aboveground and underground space

In traditional urban construction, buildings carrying important urban functions are often placed above the ground. Nowadays, with the gradual deepening of people's awareness of underground space and the shortage of urban surface land resources, some above-ground functions are gradually transferred or extended to the underground.

The core areas of new towns are positioned higher and less restricted than the parent city in terms of building height and depth. At the same time, the development of underground space has a great deal of autonomy and the need for advance planning. Therefore, it is necessary to integrate the planning of above-ground space and underground space. When rail transit and underground road systems are added to the mix, there is a greater need for integrated arrangements, complementing the functions of underground space and above-ground buildings, and guiding the underground parts of buildings to achieve connectivity and three-dimensional development. Such integration between the various functional units of the city will allow the urban space to evolve into an urban "living body" with multi-dimensional functions and composite space, and realize the coordinated development of local units for the whole.

The medium to break the boundary between the above-ground world and the underground world is often a large complex of buildings, such as stations, especially rail transfer stations and transportation hubs; commercial complexes, city squares, etc. These "hub" buildings remove barriers to travel, expand accessibility, and energize related spaces. The core area of the new town will carry the important economic activities, cultural exchanges, and transportation functions of the entire region, so it is important to seek more

space for urban construction by connecting the buildings above and below the ground, integrating the various functional areas, and ultimately realizing the efficient use of urban resources.

Nanjing's Jiangbei New Town will be one of the future economic vice centers of Nanjing, and its central business core area is the focus of underground space construction. The core area of Jiangbei New Town has a land area of about 7.5 square kilometers, with 2 million square meters of ground buildings and 3 ultra-high buildings over 300 meters. The ground-level buildings are mainly senior office buildings, luxury hotels, and various cultural and entertainment facilities. The underground space in the core area is called the "city reflection" and is connected to the above-ground buildings to form a large and complex system. The total size of the underground space is 4.5-4.8 million square meters, divided into seven functional levels, the deepest of which reaches 48 meters. The first underground level is mainly a large commercial flat. The commercial spine along the direction of Dinshan Street is linked by urban public green space, underground parks and sunken plazas. The total height of this level is 7 meters, and within 7 meters is a comprehensive commercial plaza of two to three levels. The commercial level serves as a medium to connect the above-ground buildings with the underground space, i.e., from the ground floor you can access various spaces such as the financial buildings above. Underneath the commercial level is the vehicular network system, which is planned to establish a three-level vehicular system of "underground road - underground liaison road - underground garage" to realize the rapid conversion of the peripheral expressway network and underground garage, release the space of the ground road, improve the travel efficiency and It will release the surface road space and improve the travel efficiency and environmental quality of the area. At the bottom of the underground space of Jiangbei New Town, there are two stations at the subway access level. As the core of Jiangbei New Town, the two stations are combined with pedestrian space to create a seamless "rail transit + bus + pedestrian slow transportation system" and realize an integrated transfer. At the same time, the "U"-shaped subway design is used to achieve seamless interchange between the three lines through two-two interchanges at both ends of

the platform and counter-clockwise interchange at the mezzanine level of the interchange hall. The plan also makes use of pedestrian movement to connect the two underground levels to the two above-ground levels to increase the commercial potential of the site and the overall floor value of the podium (Figure.28).

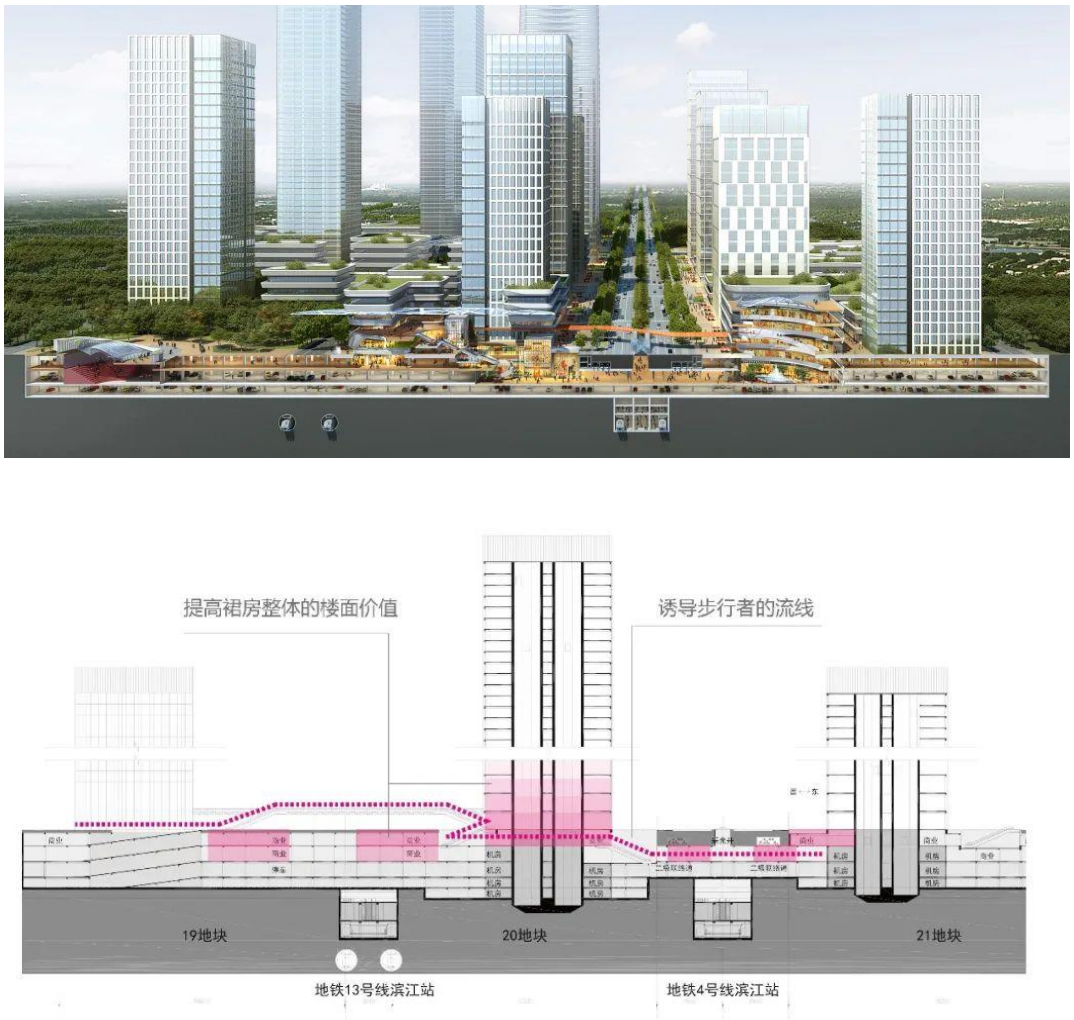

Figure 28 - Section of underground space in Jiangbei new town core area
Source: http://www.assc.org.cn/cases/9

6.1.2 Underground transportation catalyst

Traffic catalysts are derived from urban catalyst theory. The concept of "Urban Catalysts" was first introduced in 1989 by Wayne Atton and Donn Logan in their book

"Urban Architecture in America - Catalysts for Urban Design". In the design and construction of a city, the "catalysts" that stimulate and sustain the chemistry of the city may be a hotel, a shopping district, or a transportation center; they may be a museum, a theater, or a designed open space. At the same time, an urban catalyst can be a non-material factor, such as a development policy, a building idea, or an event or activity. Through the mutual stimulation and guidance of the catalysts, the city is built and the urban fabric develops gradually (Figure.29). However, the initial form of urban catalyst only works between neighboring urban parcels, but later the development is driven by the change of internal and external elements in both directions. New elements are passed through to achieve the integration of the old and the new, thus affecting a larger area. Eventually, a linkage effect of urban development is formed (Zhe, 2012).

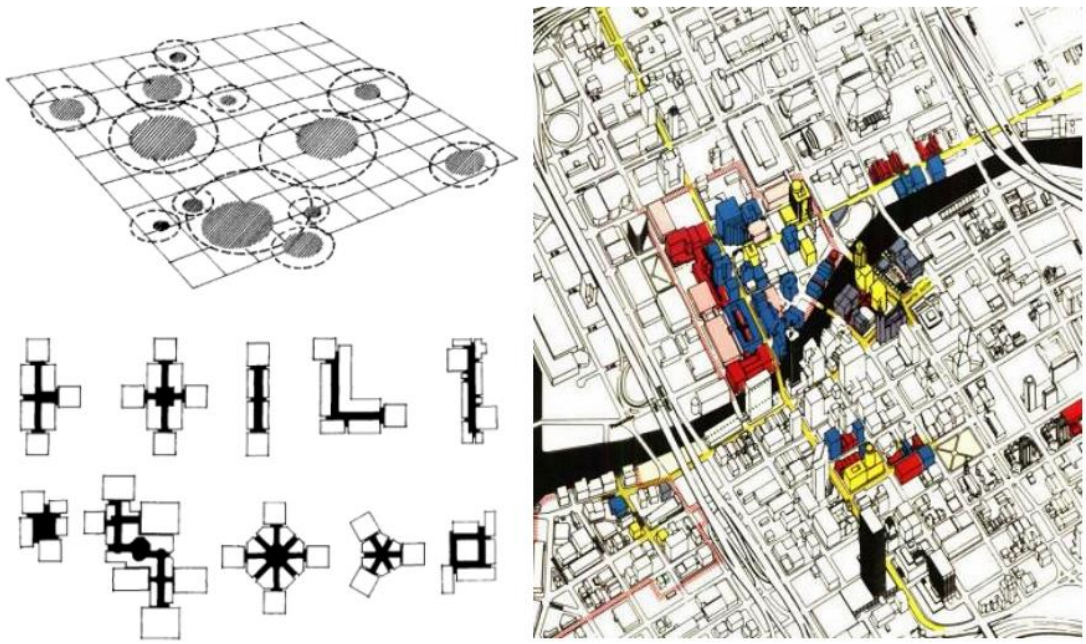

Figure 29- Catalytic Processes and Types of Urban Catalysts

Source: Wayne Atton & Donn Logan

Catalytic Processes: Actions are represented by dense parallel lines, shading represents catalytic actions, and activities such as development and renovation catalyze other actions, each of which is constrained so as not to destroy the city, and catalytic process effects are represented by shaded peripheral dashed lines. Types of catalysts: point catalysts, such as construction projects; linear catalysts, such as tracks or waterfront areas; and surface catalysts, such as patchy development or renovation. Nodal, linear and

diffuse catalysts link surrounding buildings, interacting and creating diffuse change.

Transportation system has a strong role in urban development, especially large sites such as transportation hubs, which always gather a large number of people. The gathering of people brings opportunities for all kinds of urban activities, and a series of commercial, cultural, entertainment, residential and office facilities will be built around the transportation hubs, which will eventually lead to the gathering of urban functions and the increase of urban spatial vitality and promote the intensive and efficient development of the city. Therefore, in the development of underground space in the core area of a new town, it is possible to rely on the catalytic effect of rail transit to carry out supporting planning for the surrounding above-ground and underground space. At the same time, because the new town construction has the advantage of later development, the development of underground rail transit and the surrounding space can be carried out simultaneously to avoid the subsequent repeated construction of underground space as much as possible.

The integrated rail transit hub should be combined with retail shopping as much as possible. Retail is an important part within the building of transportation commercial space. The underground passage between the passenger station and other surrounding buildings can be developed into an underground commercial street to improve the vitality of the underground passage and to make up for the investment. The underground space of Kyoto train station is the gathering place of retail, and more than 60 local specialty stores are located in the "Kyoto confectionery" and "Kyoto specialties" retail pavilions on the 1st and B1 floors of the station, selling various kinds of exquisite cakes and souvenirs (Figure.30). Porta, located in the underground area in front of the station, is a hub of pedestrian access connecting the station with the city subway, bus stations and cab stands, and has a huge customer flow (Figure.31). Porta is characterized by "fast" fashion brands, FMCG products and handicrafts, fast salon beauty services (including nail, eyelash and hairdressing), and fast food.

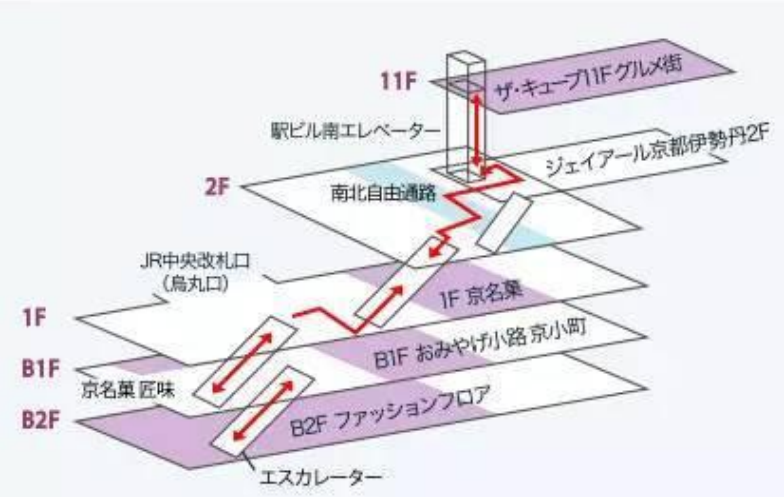

Figure 30 - The CUBE retail distribution
Source: https://www.sohu.com/a/196098950_211987

Figure 31- Porta
Source: https://www.sohu.com/a/196098950_211987

The underground transportation system not only drives the development of supporting facilities within the new town, but also strengthens the connection between the new town and the existing city, and this is especially true for Nanqiao new town. Nanjing, which has the strongest radiating effect on the development of Nanqiao new town, has 384.11 km of subway in operation by the end of 2020, and the subway is one of the most common means of transportation for Nanjing citizens to travel. If Nanqiao new town wants to strengthen the co-location development with Nanjing, it should actively build its own

underground transportation system and dock with Nanjing's underground transportation system, which will help the circulation of population between Nanqiao new town and Nanjing. Once the population circulation is active, it can lead to the circulation of capital, technology and other production factors, creating opportunities for the urban development of the new town.

6.1.3 Three-dimensional pedestrian system

A convenient automobile transportation system and a comfortable pedestrian environment are the transportation environments on which the urban core thrives. However, radical separation of pedestrian and vehicular planes, or separation of pedestrian and vehicular above and below ground, is weakening the accessibility of urban cores. People are the source of urban vitality, so a three-dimensional pedestrian system is needed to enhance the circulation of people and promote the interoperability of all urban spaces. In China, subway construction is in full swing, and commercial, entertainment and other types of functions are moving underground, implying the extension of urban public activities underground (Dong, 2008). For example, subway stations require a public activity process from the surface to the underground ticket gate, and in addition to the act of transportation, this process can also occur in the act of activities such as ticketing, shopping, dating, and even dining.

Therefore, when planning the core area of a new town, the limited space resources can be fully utilized through a three-dimensional pedestrian system, and the land can be developed in an integrated way above, below and above ground. Walking is one of the most common ways for people to carry out urban activities, and the three-dimensional pedestrian system is an important driving force for the intensive operation of the city, which can improve the efficiency of the city, optimize the urban environment, and promote the sustainable development of the city.

There are three main forms of urban three-dimensional pedestrian system: aerial

pedestrian subsystem, surface pedestrian subsystem and underground pedestrian subsystem.

The aerial pedestrian subsystem refers to the use of above-ground street crossings or pedestrian bridges to connect urban facilities above the ground level, forming a set of pedestrian space system independent of the ground level streets. The underground pedestrian system is the counterpart of the aerial pedestrian subsystem, which cannot be simply equated with a simple underground walkway. From the perspective of the current development trend, it has evolved from the early purely transportation nature to an "underground complex" that includes a variety of urban functions and is composed of transportation, commercial and other facilities that are interdependent. The underground pedestrian subsystem is more effective than the prosperous commercial character in that it enables the management and improvement of traffic conditions in busy urban areas.

Both the aerial pedestrian subsystem and the underground pedestrian subsystem need to be connected to the surface pedestrian system in order to maximize connectivity. The ground-level pedestrian subsystem is the foundation of the entire three-dimensional pedestrian system and the hub of connectivity. There are two common ways to connect the pedestrian system with underground space development: underground pedestrian subsystem and ground pedestrian subsystem; and the integrated pedestrian system formed by the combination of air pedestrian subsystem, ground pedestrian subsystem and underground pedestrian subsystem.

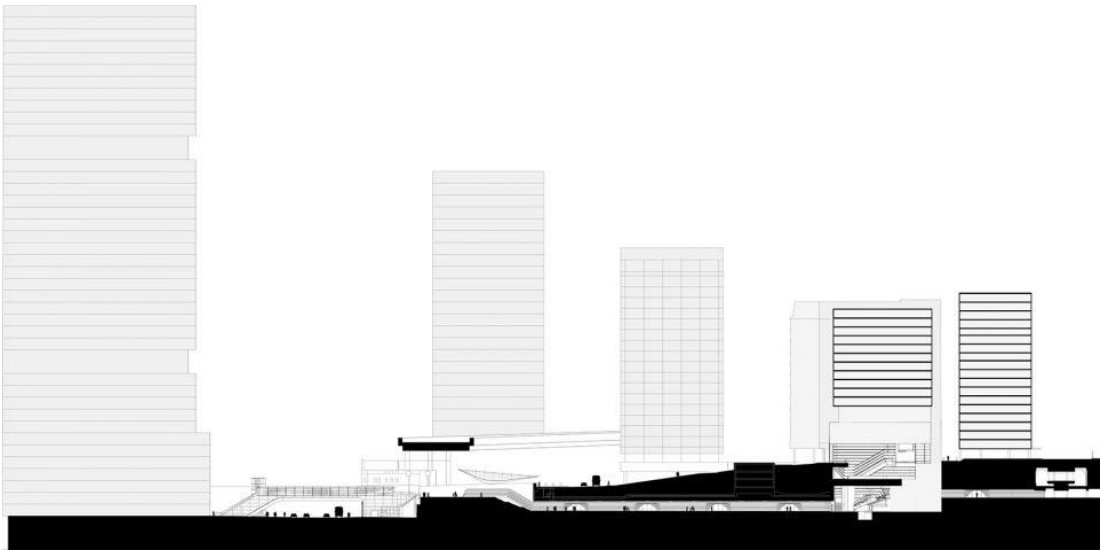

Figure 32- Wynyard walk, Sydney, Australia

Source: https://www.sohu.com/a/196098950_211987

A three-dimensional pedestrian system that functions solely as a linkage. the Wynyard walk including the ground and underground level of pedestrian. Connecting one of Sydney's busiest transport interchanges to Barangaroo through architectural expression, Wynyard Walk has created a unified identity and civic presence, delivering a socially sustainable piece of infrastructure to Sydney's CBD.

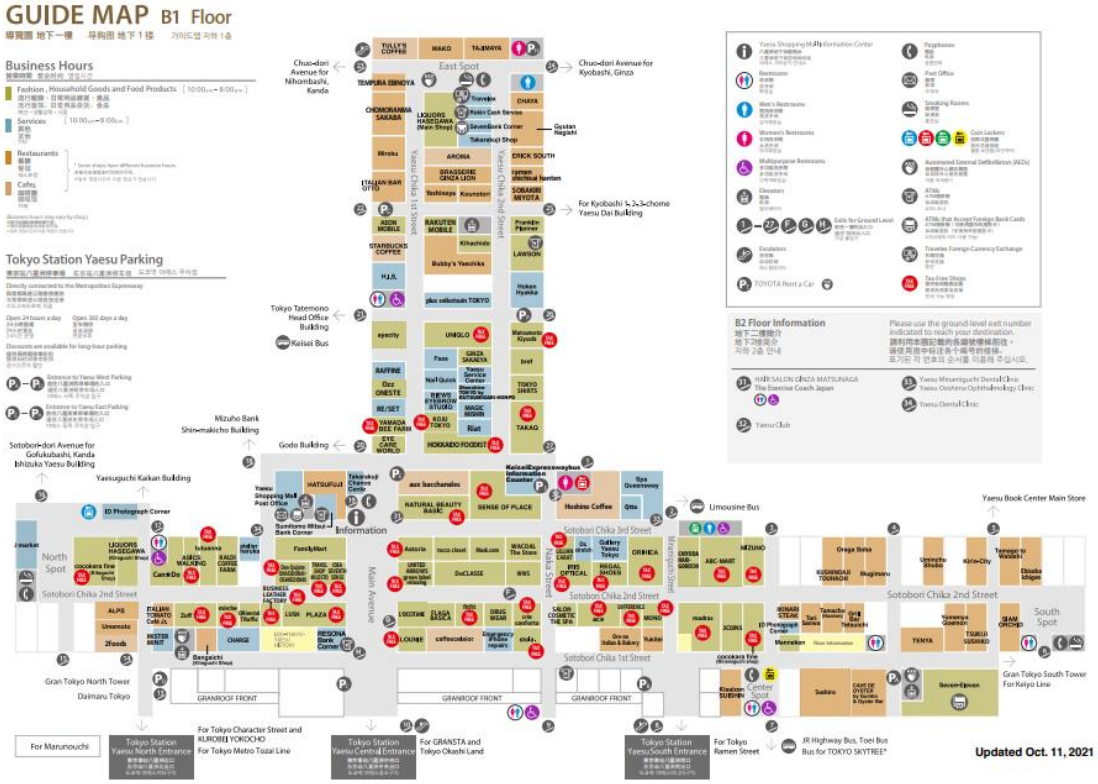

Figure 33 - Map of Yaesu Underground Pedestrian Street, Tokyo, Japan

Source: https:// Yaesu.mall /a/196098950_211987

Map of Yaesu Underground Pedestrian Street, one of the largest such malls in Japan, is directly connected to Tokyo Station. It contains about 180 shops, which include a rich assortment of approximately 60 different restaurants and cafes. The vast underground street is distributed with many steps, escalators and elevators connecting to the ground for pedestrians to enter and exit freely.

At present, the cities with well-developed three-dimensional pedestrian systems are mainly concentrated in developed countries where the urban system operates under greater pressure, such as Tokyo in Japan, Minneapolis in the United States, and Hong Kong in China. The higher the volume of urban activity, the higher the possibility of a pedestrian system, such as the commercial center of the city, the financial office district or the transportation hub of the city, and so on. Therefore, the establishment of a three-dimensional pedestrian system in the core of a new town needs to take into account the scale of the new town, the economic level, the population density and other factors. In particular, the scale of the pedestrian system and the way it is connected need to refer to the master plan of the new town so that it can be fully compatible with the operation of the new town' s core area without wasting land or money.

6.2 Nanqiao new town underground space multifunctionalization

When developing the underground space of a new town, multi-functional use should be taken into consideration, which is conducive to resource conservation. The most common way of multi-functional underground space is to use the combination of civilian and military functions and disaster prevention functions. Underground space has excellent performance in terms of confinement, high protection, thermal insulation, and thermal stability, which makes it an excellent shelter for air and disaster prevention. In addition, the development of some underground spaces can serve to alleviate urban diseases and reduce the threat of natural disasters to cities, in addition to meeting people's daily needs. It promotes the urban environment to become resilient, livable and sustainable.

6.2.1 Evacuation function and other functions

In the development of countries all over the world, underground air and disaster prevention facilities are regarded as an indispensable part of urban construction. Underground buildings with wartime defense tasks increase the investment by about 5-20% compared with ordinary underground buildings, and this investment is difficult to produce benefits in peacetime, while some protective facilities also cause a certain degree of inconvenience to the use in peacetime (Xie, 2013). At the same time, even in new towns, land resources are very valuable, and if all disaster and air defense facilities are new underground spaces specially developed, it will undoubtedly cause a waste of financial resources and resources. Therefore, some underground spaces should be planned as dual-use spaces for air and disaster prevention and urban public activities during the safety period.

During the security period, these underground spaces serve all kinds of urban activities according to their original functions to avoid the space from being deserted. In times of war and natural disasters, certain transformation and reinforcement measures will be taken to transform them into places suitable for people to take refuge. The design of such reinforcement should be simple and easy to implement, and the reinforcement materials should be easy to obtain, so that the materials can be taken locally or nearby; the reinforcement measures should be convenient and quick, so that non-professionals can also operate, etc. In the design of the future reinforcement measures should be fully considered, in advance of the design of the pre-buried parts, not only to facilitate the use of the usual, but also in the event of danger can be quickly converted to meet the protection requirements.

There are many types of underground spaces developed in a city, but not all types of underground spaces are suitable for functional conversion and transformation into air and disaster prevention facilities. In some countries, underground public spaces become potential human defense facilities. Underground garages are extremely important and vast civil facilities in underground space that are well suited for conversion into shelters. In Paris, there are more than 80 underground garages built in the city, which can accommodate more

than 43,000 cars and make some personnel shelters on its basis, attaching great importance to its wartime protection. Russia has the world's largest subway trunk line, and the subway transportation network is linked into a network. Moscow's subway network alone is 300 kilometers long, with 9 lines, including 8 auxiliary lines and 1 loop line, with 150 platforms and 4,000 subway trains, carrying more than 9 million passengers a day and 45% of the city's passenger traffic (Figure.34). These subway networks can serve as a cover for people in case of emergency (Zhang, 2009). It should be noted, however, that not all parts of the subway are suitable as shelters, and when air strikes come, the first to be destroyed are strategically important facilities such as transportation hubs. Therefore, only the non-hub areas of the subway are suitable as shelters. after 9/11, the United States has invested a lot of human, material and financial resources in the construction of civil defense projects, and has built a large number of underground projects for the conversion of civilian and combat functions. For example, the classrooms, laboratories and various activities of the civil engineering department of the University of Minnesota are all built underground, and the whole building has seven floors underground, with a total depth of more than 30 meters; the Los Angeles City Library has four floors above ground and four floors underground, and the stairs are designed to be reduced floor by floor, taking into account the design of the landscape and the spatial experience of people, creating a very good reading environment (Figure.35). These spaces are used for work, study, entertainment and other activities during normal times, and become convenient places of refuge in times of war.

Figure 34 - Moscow Metro
Source: http://travel.qunar.com/p-pl4905897

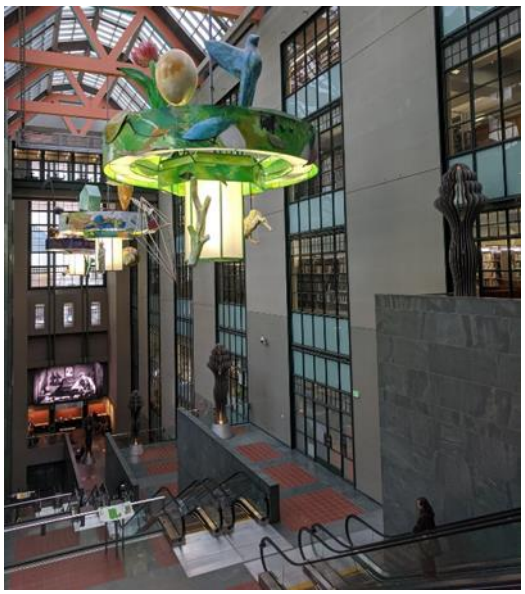

Figure 35 - Los Angeles Library underground stairs
Source: https://www.lapl.org/branches/central-library/departments/popular-library/map

6.2.2 Resilient function and other functions

Among natural disasters, earthquakes, explosions, fires, and wind damage can be mostly mitigated by the characteristics of the underground space itself, but floods can be a greater threat to the underground space. However, underground space can be used to store

flood water and thus mitigate the impact of flooding on cities. In the context of rapid global climate change, new towns should develop an appropriate amount of underground space for flood prevention to avoid future problems of urban flooding due to hardening of the ground.

Some cities have set up sunken green areas in various public green areas and squares, community green areas, and protective green areas, which can also serve the function of retaining some rainwater. Sinking green space such as depressions, rainwater ponds, rain gardens and other such ecological rainwater facilities can not only promote urban drainage, but also other functions that promote sustainable urban development. For example, rain gardens can effectively remove suspended particles, organic pollutants, and harmful substances such as heavy metal ions and pathogens from runoff. Rain gardens usually use native plants to provide a good habitat for insects and birds, while also providing a new landscape perception and visual experience. Rain gardens can regulate the humidity and temperature of the air in the environment through the transpiration of the plants, improving the microclimate. In addition, rain gardens are less expensive to build and easier to maintain and manage than lawns.

The rain garden of Beijing 768 Creative Park effectively infiltrates, retains, purifies, accumulates, utilizes, and discharges rainwater from the roof of the building and surrounding sites, and manages rainwater to become a real rainwater bank. At the same time the layered design attracts many people to come here to rest, play and communicate, bringing good social benefits to the community (Figure.36).

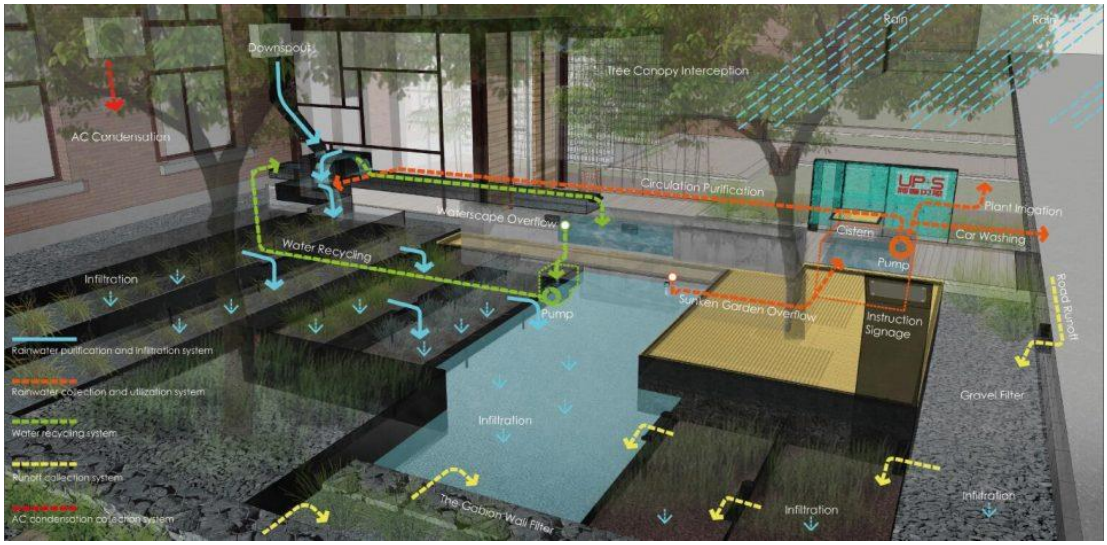

Figure 36 - Rainwater system

Source: https://www.gooood.cn/rain-garden-ups.htm

Rooftop and driveway runoff flows through a series of bioretention terraces before infiltrating through the central sunken garden. An underground cistern provides additional storage during extreme rainstorms. Purified rainwater is reused for irrigation, car-washing and waterscape in two linear troughs.

6.3 Nanqiao new town underground space development in an environment-friendly way

The construction of new towns always destroys the original natural environment or rural landscape and breaks the original ecological balance, so it is necessary to develop underground space to minimize the negative impact of above-ground buildings on it. For some special function buildings, such as libraries, museums and art galleries, the construction can be moved from the ground into the underground, preserving the original landscape of the ground.

For example, most of the buildings in Tadao Ando's Chichu Museum are buried underground, and when viewed from the sky, they look like many hollowed-out blocks embedded in a hillside. The lighting is designed to maximize the effect of natural light, which is carefully designed to form an important part of the artworks on display. At the same time, the building is buried in the ground to preserve the natural landscape of the area to the maximum extent possible. These elements make the Chichu Museum a model of site-specific

art. Embracing nature and appropriate to the site, the Chichu Museum presents a vision of a sustainable underground environment. Through this work, Andō Tadao expresses the interaction between people, architecture and nature, hoping to raise awareness of sustainability and to participate in the protection of the natural environment (Figure.37).

Figure 37- Chichu Museum

Source: Chichu Museum Official website, 2021, https://benesse-artsite.jp/en/art/chichu.html

TIRPITZ in Denmark is known as the hidden museum (Figure.38). The new TIRPITZ Museum transforms a historic German World War II trench into a groundbreaking cultural complex. In contrast to the large and intrusive volumes of the site's artillery fortress, the newly built TIRPITZ Museum is a simple, pure concrete mass, carefully embedded in the sand dunes along the shore, hidden in camouflage beneath the landscape. The building consists of four main materials and elements which are also found in the existing structures and natural landscape of the area – concrete, steel, glass and wood. The walls of the exhibition rooms are made of concrete cast onsite, supporting the landscape and carrying the fascinating roof decks that cantilever out 36 m. “TIRPITZ is a unique opportunity to combine nature and culture in a spectacular fashion. A visit to the museum is not a visit to an exhibition gallery, but a scenic journey through time and space of West Jutland. The idea is that the whole place itself comes to life following the rhythms of nature.” (Erik Bär, Partner/Director, Tinker Imagineers)

Figure 38 - TIRPITZ
Source: Rasmus Bendix, 2018

Compared with aboveground buildings, underground space can not only reduce the damage to the original landscape, but also reduce the pollution to the environment. In the construction of some new towns in China, some excessively wide roads are planned on the surface. Such a grand surface transportation system not only wastes land resources, but also tends to cause environmental pollution in the process of future use. Motor vehicles on the ground emit a lot of exhaust fumes, reducing air quality and causing the greenhouse effect, and the noise generated by vehicles can even endanger people's physical and mental health. However, the existence of underground transportation system can reduce the use of land on the ground, reduce the air pollution and noise pollution from vehicles driving on the ground space, and help the efficient and sustainable development of the new town.

6.4 Nanqiao new town underground space connected development

In a city, underground space from the emergence to maturity is the process from point-like underground space to linear underground space, and finally form a network-like underground space. In this process, connectivity design refers to promoting the integration

and utilization of underground space formally through connectivity engineering, mainly including the connectivity of underground space with the same function, the connectivity of underground space with different functions, and the connectivity of underground space around rail transit. When planning underground spaces in new towns, planners should take into account the relationship between various functional underground spaces and prepare adequate measures for current and future underground space connectivity. Underground spaces of the same function can coordinate with each other and cooperate to play a greater role; underground spaces of different functions can form functional complementarities through connectivity, catalyzing each other and optimizing the quality of underground space.

Figure 39 - Toronto PATH Development Process Map

Source: Zhou Xu，2017

In the first stage commercial groups built underground passages to attract traffic, connecting the ground level with the underground spaces of department stores, hotels and train stations, which are individual actions. In the second phase the government encouraged underground spaces to connect with each other. Subway spaces were connected to PATH, and many subway switching stations and concourses were connected to neighboring commercial buildings and retail stores through PATH. In the third stage the government is responsible for the city-wide coordination of PATH and systematically strings together many department stores, hotels, office buildings, and subway stations with PATH, forming a PATH corridor system for the city's underground street life. PATH brings substantial contributions to the city,

not only providing convenience for pedestrian travel, but also increasing economic income and employment opportunities in the downtown area, driving related business and retail service development.

The most typical of the underground space connections for the same function is the underground transportation facilities that can effectively promote the accessibility of the area. In many new underground urban complexes, underground pedestrian systems, subways, underground motorways and garages are connected to each other by elevators, stairs and other auxiliary facilities, providing a great convenience for people to transfer between them.

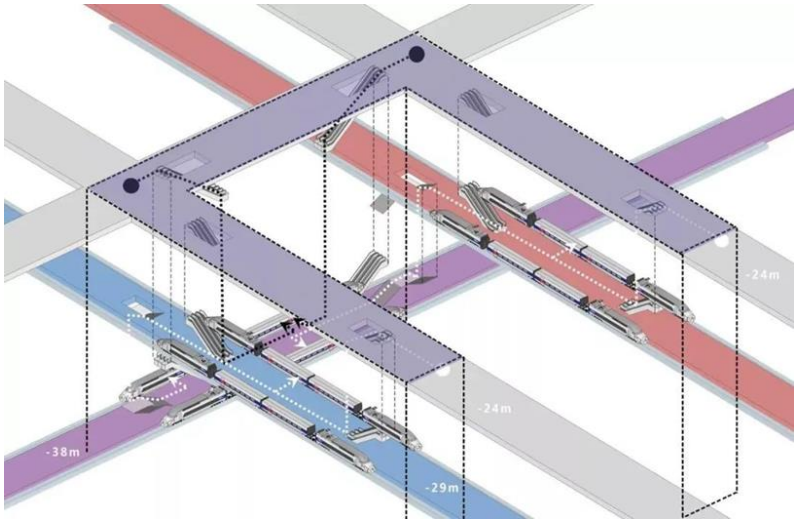

Figure 40 - Connecting underground transportation facilities in Jiangbei new town
Source: http://travel.qunar.com/p-pl4905897

An example of connecting different functional underground spaces to promote regional development is that the connection between underground rail transit and underground commercial can promote crowd consumption and increase the economic benefits of the underground space. In terms of behavioral categories of consumption, induced consumption is generated in commercial spaces in integrated rail transit hubs, which is a more random and highly indeterminate consumption activity. It is usually the consumer's impulse to participate in traffic or other activities in the space of the rail transit

integrated hub, which is triggered by the lure of certain information (Chu, 2013). Therefore, the commercial space with comfortable environment and safe space based on rail transit is more likely to stimulate more commercial consumption behavior, which is why the subway interchange space is always full of retail merchants.

Comprehensive utilization of underground space around rail transit land mainly includes underground space connectivity along both sides of the rail line and underground space connectivity around the rail station. On the one hand, it can solve the problem of ground-level pedestrian crossing, and on the other hand, it can also be used as a human defense evacuation channel in times of war. According to the different relationships between subway stations and roads and plots in horizontal and vertical directions, the connection between subway stations and the surrounding underground space can be divided into five kinds of spatial relationships: channel connection, common wall connection, sunken square connection, integrated connection and vertical connection.

Although the underground space connection project is a gradual process with urban development, in the early stage of new town construction, urban builders need to plan the connection project according to the current situation, positioning and future development expectation of the new town in an appropriate amount. For the developed underground space, it is possible to set up additional facilities such as connecting channel entrances and air shafts; for the undeveloped land of the new town, it is necessary to propose corresponding index control guidelines for underground space such as reserved underground entrances and exits, reserved underground connecting space and underground development depth.

Conclusion

This study aims to investigate the strategies of underground space development in new towns in China to reduce the difficulties encountered in the development of new towns and promote the positive role of new towns in urban development. The background of the emergence and development of new towns in China, i.e., the urbanization process in China, was first reviewed. Through the review of a series of policies since the reform and opening up (1978), it was understood that the central government in China had taken measures to promote urbanization in a concerted manner in four areas: urban construction, economic development, decentralization reform and social management. While the central government has set the overall institutional and policy framework for urbanization, China's urbanization has shown regional variation depending on the actions of local governments. Local governments usually promote urbanization in their respective jurisdictions through administrative reorganization, institutional innovation (administrative system, land system, household registration system, etc.), policy incentives, and development zones. Examples are given to discuss how different levels of local governments and special economic zones have refined central policies, promoted implementation, and solved various urbanization dilemmas.

Government-action-driven urbanization has also created several significant features of China's urban transformation. Urban expansion centered on planning, with the market as a government tool to advance urbanization. Behind the exaggerated pace of urban expansion is that local government officials seek DGP growth and do their best to accommodate central government policies. One of the manifestations of such rapid urban expansion is the mushrooming of new towns that have taken over the urban fringe and rural areas. In terms of urban-rural governance, China's cities and villages have a complex phenomenon of dichotomy or unity, which is also influenced by the economic capacity of local governments. For example, economically developed regions such as Jiangsu and Zhejiang have a much

higher degree of urban-rural integration than other regions in China. In addition, various types of migrants bring informalities to China's regular urbanization process, such as gentrification, urban villages, and ethnic ghettos. This informality reflects the contradiction between the policy system and human initiative and the government's compromise.

As an essential product of China's urbanization, the new towns are the subject of this study to explore the underground space development strategy. Before determining the underground space development strategy, this thesis first analyzed the legislative process of new towns, which could be roughly divided into three legislative stages according to the development process and policy formulation of various types of new towns: the initial exploration stage of new town legislation from 1979 to 1988; the differentiation stage of local, new town legislation from 1988 to 2006; and the breakthrough innovation stage of new town legislation from 2006 to the present. In the past hundred years, new town construction has been a successful model for cities to divert population and industry from the main urban areas, prevent the spread of urban pie, and solve urban diseases. In China, it is no exception. The cases of new towns in Shanghai, Beijing and Nanjing show that new towns have made outstanding contributions in absorbing people for employment and residence, promoting urban economic development and industrial upgrading, evacuating urban functions and optimizing urban spatial structure.

However, China's new towns have also brought problems while promoting urban development. The large-scale construction of new towns in China has led to severe land wastage. The land area for construction in some new towns has dramatically exceeded the approved urban construction land control index. Some new towns have even greatly exceeded the area of existing cities. This waste is caused by the upper statutory plan (district and county general plan) breaking through the general plan of the city where it is located, the failure to adjust the control plan in time after the adjustment of the upper statutory plan, and the breakthrough of the statutory plan based on the non-statutory plan (strategic plan). The development of new towns in China mainly relies on occupying the original agricultural land or the natural landscape at the edge of the mother city, causing environmental damage.

Some new towns are overbuilt, causing waste of resources. In contrast, others fail to attract people to live there because of inadequate infrastructure, separating industrial development from urban development. In addition, the functional positioning of some new towns is not precise, and the urban functions of new and old cities gradually converge. The examples of Binhai New Area, Caofeidian New Area, Bohai New Area and other new port towns reflect the severe homogenization of new town positioning.

The problems of new towns can seriously hinder the advantages of new towns, so this thesis discussed the strategies to solve the problems of new towns. Many urban planners have compensated for the problems of existing cities by building underground space, so the development of underground space also offers the possibility to solve the problems of new towns. The role of underground space construction for new towns is summarized by understanding the functions and characteristics of underground space. As an additional spatial resource, Underground space contributes to the compact development of new towns and has great potential for efficient land use. The urban catalytic effect reflects that underground transportation space, mainly the metro, can promote the construction of surrounding facilities and stimulate the vitality of new towns. Underground space has an excellent performance in high protection, thermal insulation, thermal stability and confinement, and underground air and disaster prevention facilities can provide a safe, stable and resilient development environment for the new town. On the other hand, underground space construction can reduce the damage to the surface landscape and help maintain the ecological balance of the micro-region. Underground transportation system also proves that underground space can effectively reduce air pollution.

In order to explore the specific strategy of underground space development in new towns, this thesis took Nanqiao new town as a case study. Nanqiao new town is a typical case in the category of new towns that have been upgraded from development zones to integrated towns during the urbanization process in China. After the reform and opening up, Wuyi Town, the foundation of Nanqiao new town, formed an industrial agglomeration through industrialization and accumulated a large population. However, during the

development process of Nanqiao new town, it also encountered problems such as the giant land planning area of the new town, the destruction of the ecological environment, and the infrastructure not meeting the needs of people's life. In the face of the strategy of developing underground space in Nanqiao new town, this research adopted a combination of quantitative research and qualitative research mode, firstly, through secondary data analysis and fieldwork to understand the construction of underground space in Nanqiao new town. It was found that the underground space in Nanqiao new town is unevenly distributed, with a single functional composition, mainly for parking, and a shallow development depth. The study found that the underground space in Nanqiao new town is unevenly distributed, with a single functional composition, mainly parking, and shallow development depth.

In order to avoid wasting resources and reasonably develop the underground space in Nanqiao new town, this thesis predicted the future demand for underground space in Nanqiao new town by the land classification prediction method, using 2035 as the time boundary. The total demand is 1.789-1.909 million square meters, of which the total rigid demand is 1.68 million square meters, and the elastic demand is 109,000-229,000 square meters. Then the demand for underground space per capita was calibrated with the amount of underground space planned to be developed in 2035 in other cities and new towns at the same economic level. The predicted result is in line with the development demand of cities at the same level.

For the location positioning of underground space development in Nanqiao new town, the suitability assessment of the resources and environment of Nanqiao new town was carried out, mainly including the assessment of the natural environment and socio-economic conditions. Five elements of topography and geomorphology, rocks and soil, geohazards, groundwater and ecological sensitivity, were selected as evaluation indicators in assessing the natural environment. The total order of weights was determined according to the development depth. Finally, ArcGIS was applied to visualize the data to derive the evaluation results. The same method was also used to evaluate the socio-economic conditions, and the

selected evaluation indexes were population pressure, traffic conditions and urban functions. The final result: the critical construction areas for underground space in Nanqiao new town are the two stations of the Chu-Ning Express Railway and their surrounding areas and the two future commercial and entertainment centers. The underground space in these areas has great potential, so developing -10~-30m depth is recommended. Natural lakes and rivers are prohibited areas for construction as protected areas. Agricultural land and industrial storage sites are restricted areas, and the rest of the large urban areas are suitable for underground space.

Finally, the following conclusions were drawn from various case analyses regarding underground space's functional positioning and development mode in Nanqiao new town. Nanqiao new town should first focus on developing underground space in the core area of the city. Integrate aboveground and underground space to promote complementary urban functions; use underground transportation as a power source to drive the establishment of various functional facilities around the city to form an intensive and efficient new town center; establish a three-dimensional pedestrian system to promote the accessibility of aboveground and underground space and introduce human flow to enhance the vitality of urban space. Secondly, the construction of multi-functional underground space can reduce the waste of space resources; for example, the air and disaster prevention facilities used for refuge in times of crisis can be used for other urban functions such as entertainment and education in times of peace, providing more space for people's urban activities. Thirdly, underground space development can reduce the construction of surface buildings, thus reducing the damage to the surface landscape caused by the development of new towns. Finally, the design of the underground space of the new town is connected to promote the coordination of various functional spaces and lay the foundation for the future construction of the underground space of the new town.

The moderate development of the underground space of the new town can effectively alleviate the problems faced by the development of the new town and promote the new town to play its beneficial role. However, since underground space is more costly

than aboveground buildings, the development of underground space in new towns should be done according to the level of GDP of the new town and the functional positioning of the city. It is also a severe waste of resources if underground space is overdeveloped. This thesis failed to explore the relationship between the development of underground space in a new town and the level of economic development of the new town, which is an aspect that can be explored in-depth in subsequent studies.

Reference

Arkaraprasertkul, N. (2018). Gentrification and its contentment: An anthropological perspective on housing, heritage, and urban social change. *Urban Studies,55*(7),1561–1578.

Besner, J. (2002, November). The Sustainable Usage of the Underground Space in Metropolitanarea, *ACUUS International Conference Urban Underground Space: A Resource for cities,* (14-16). Montreal, Australia: International Affairs Office, City of Montreal.

Bobylev, N. (2009). Mainstreaming sustainable development into a city's Masterplan: A case of Urban Underground Space use. *Land Use Policy, 26*, 1128–1137.

Bobylev, N. (2016). Transitions to a high-density urban underground space. *Procedia Engineering, 165*, 184 – 192.

Chen, J., & Shi, X. (2007, September). A probe into the development and utilization of underground space of new towns in Beijing, *11th ACUUS Conference* (pp. 297–302). Greece, Athens.

Chen, W., Song, W., & Yang, G. (2013). Urbanization Development Situation, Momentum and Trend of Urban Dense Areas in the Yangtze River Delta. *Proceedings of the Chinese Academy of Sciences,01*, 28-38.

Chen, Z. (2011). Political Economy of China's Urban and Rural Development. *Southern Economy,* (08),3-17.

Chiu, R. L. H. (1996). Housing affordability in Shenzhen Special Economic Zone: A forerunner of China's housing reform. *Housing Studies,11,*561–580.

Chu County District Local History Compilation Committee. (1991).*Chuxian District Records.* Beijing, China: China Literature and History Press.

Ding, Z. Y. (2013). *Research on the Development of China' s Housing Market in the Process of Urbanization* (Doctoral dissertation). Retrieved from China HowNet (Accession No. F299.23)

Dong, J., Zhang, W. B., & Gong, W. (2021). Towards co-governance of urban and rural areas: Interpretation of the evolution of urban-rural relations since the reform and opening up.

Progress in Geography,40(5),883–896.

Gan, Y. (2017). Countermeasures for micro-renovation of village community environment in Guangzhou. *Cities,46*(4),30–38.

Gao, M. (2018). Analysis on Evaluation Technology of Urban Underground Space Resources Based on GIS Analysis. *Urban Road Bridge and Flood Control, 2*(2), 183-189.

Garreau, J. (1991). *Edge City: Life on the New Frontier.* Doubleday, New York.

Gao, B., & Ge, Y. (2011). Countermeasures and policy recommendations for the development of new urban districts. *Journal of Economics,* (11),13-18

Governa, F., & Sampieri, A. (2018). Urbanisation processes and new towns in contemporary China: Acritical understanding from a decentred view. *Urban Studies,57*(2),366–382.

Guan, Y. (2014). Thinking and Countermeasures of Jiangsu Beautiful Countryside Construction. *Jiangsu Agricultural Science,42*(6),13-15.

Gui, J., & Hu, H. (2020). Exploration on the Evaluation and Control of Underground Space Resources in Small and Medium-Sized Cities of Yunnan. *Urbanism and Architecture, 10*(17), 28-30.

Han, G., & Leng, J. W. (2021). Research on the Integration Design Strategy of the Ground and Underground Space in the New Urban Area: A Case Study of the Core Area of Science and Technology Innovation City in the West of Hangzhou. *Urban Construction, 02*, 173-175.

Harvey, D. (1989). From managerialism to entrepreneurialism: The transformation in urban governance in late capitalism. *GeografiskaAnnaler71B*,3–18.

Harrison, J. (2014). Rethinking City-regionalism as the Production of New Non State Spatial Strategies: The Case of Peel Holdings Atlantic Gateway Strategy. *Urban Studies,51*(11),2315-2335.

He, S., & Qian, J. (2017). From an emerging market to a multifaceted urban society: Urban China studies. *Urban Studies,54*(4),827–846.

Hou, M. (2013). *Research on Demand Forecast and Development Control of Underground Space in Tianfu New Area* (Doctoral dissertation). Retrieved from China HowNet(Accession No. TU984.34)

Hong, K. (2004). Analysis of the phenomenon of "economic development zone fever". *Journal of South China Agricultural University,4*(3),67–72.

Hong, Y. (2004). *Research on the Life Cycle of Development Zones——From the Perspective of Institutional Evolution* (Doctoral dissertation). Retrieved from China HowNet(Accession No. TU984.34)

Hong, Z. (2019). Evaluations on the Sustainable Exploitation and Utilization of Urban Underground Space in Xi'an. *Journal of Xi'an Shiyou University (Social Science Edition), 28*(3), 108-121.

Hu, Z. Y., Jiang, C. & Li, Y. (2021). A study on the effect and mechanism of industrial structure transformation in national-level new districts. *Journal of industrial Technological Economics, 09,* 115-125

Jia, S. P., & Li, W. P. (2008). Review of Research on Evaluation of Urban Underground Space Resources. *Chinese Journal of Underground Space and Engineering, 4*(3), 398-402.

Jiang, Y., Waley, P., & Gonzalez, S. (2016). Shifting land-based coalitions in Shanghai's second hub. *Cities, (52)*,30–38.

Jiang, B. Z. (2020). Research on the Construction of China's State-level New Areas and Its Impact on Urban Economic Growth (Doctoral dissertation). Retrieved from China HowNet (Accession No. D630; F984.21)

Knox, P. (ed.) (1993). *The Restless Urban Landscape.* Englewood Cliffs, NJ: Prentice Hall.

Lefebvre, H. (1991). The Production of Space. London: Blackwell.

Li, Q. (2007). Discussion on the Strategic Decision-Making Mode of Urban New District Development. *Urban Development Research,* (5),24.

Li, Q., Chen, Y. L., & Liu, J. M. (2012). Research on the "Promotion Mode" of China's Urbanization. *Chinese Social Sciences,7*(82),100.

Li, Y. (2018). Understanding city-regionalism in China: regional cooperation in the Yangtze River Delta. *Regional Studies,52*(3),313-324.

Li, Z., L i, X., & Wang, L. (2014). Speculative urbanism and the making of university towns in China: A case of Guangzhou University Town. *Habitat International,44*,422–431.

Li, Y., & Wu, F. (2018). Understanding city-regionalism in China: regional cooperation in the Yangtze River Delta. *Regional Studies,52*(3),313-324.

Li, H. & Zhou, L. (2005). Political turnover and economic performance: The incentive role of personnel control in China. *Journal of Public Economics, 89*,1743–1762.

Liang, H. Z. (2010). *Research on the construction and development model of urban new districts* (Doctoral dissertation). Retrieved from China HowNet (Accession No. TU984.18)

Lin, Y. (2017). The constitution of special economic zones revisited. *Strategies, 05*, 179-186.

Liu, Y.& Wu, F. (2015). Urban poverty neighbourhoods: Typology and spatial concentration under China'smarket transition, a case study of Nanjing. *Geoforum,37*(4),610–626.

Lu, J., & Chen, Y. (2012). Integrated design of Under-and Above-ground Urban Space: Strategies for Effective Development of Underground Space. *Journal of Shanghai Jiaotong University, 46*(1), 33-40.

Liu, L., Huang, Y.Q., & Zhang, W. H. (2018). Residential segregation and perceptions of social integration in Shanghai, China. *UrbanStudies,55*(7),1484–1503.

Lin, G. (2014). China's landed urbanization: Neoliberalizing politics, land commodification, and municipal finance in the growth of metropolises. *Environment and Planning, A46*,1814–1835.

Liu, N. (2013). *A study on the impact of university parks on urban development* (Doctoral dissertation). Retrieved from China HowNet(Accession No. D630;F299.21)

Logan, J. R. (2018). People and plans in urbanizing China: Challenging the top-down orthodoxy. *Urban Studies,55*(7),1375–1382.

Lu, X. H., & Wang, C. W. (2016). Reflections on the legislation of national-level new district regulations - taking the drafting of the regulations of Xi'an New District in Shaanxi Province as an example.36, 70-74.

Ning, Y. M. (1993). Several problems of urban network optimization under market economy conditions. *Urban Issues,04*(56),2-6.

Ouyang, Y. X., & Wang J. (2018). Planning and Design of Underground Space in the Construction of New Urban Districts. *Beijing Planning and Construction, 03,* 111-115.

Parriaux, A., Blunier, P., Maire, P., & Tacher, L. (2006, September). The DEEP CITY Project: A

Global Concept for a Sustainable Urban Underground Management. *IAEG 2006 Engineering geology for tomorrow's cities.* Nottingham.

Park, E. J., & Kang, E. (2021). Sublime Experience for Sustainable Underground Space: Integration of the Artists 'Works in Chichu Art Museum. *Sustainability, 13*, 1-15.

Peng, F. L., Qiao, Y. K., Zhao, J. W., Liu, K., & Li, J. C. (2020). Planning and implementation of underground space in Chinese central business district (CBD): A case of Shanghai Hongqiao CBD. *Tunneling and Underground Space Technology, 95,* 103176. https://doi.org/10.1016/j.tust.2019.103176

Peng, J., Peng, F., Nobuyoshi, Y., & Tomohiro, F. (2019). Factors in the development of urban underground space surrounding metrostations: A case study of Osaka, Japan. *Tunnelling and Underground Space Technology, 91*, 103009.

Qu, T., Cai, J. M., & Dong, M. (2009). Administrative Division Adjustment and Urban Development Change. *Urban Issues,2*,32-36.

Shao, M. (2021). Research on urban underground space resource assessment and demand forecasting method——Taking Zhuhai Hengqin New Town as an example. *Housing Studies, 13,* 54-63.

Shen, J., & WU, F. (2016). The Suburb as a Space of Capital Accumulation: The Development of New Towns in Shanghai, China. *Antipode,49*(3),761–780.

Sterling, A., & Bobylev, N. (2012). Sustainability issues for underground space in urban areas. *Urban Design and Planning, 165*(4), 241-254.

Sun, S. (2010). Well-being and optimization of immigration space. *Economic Research,49*(1),97-111.

Tan, B., & Huang, Y. (2013). On the reform path of legislation for special economic zones in China. *Journal of Jianghan University (Social Science Edition), 30*(3), 50-54.

Tian, X.B. (2021). Progress, dilemma and breakthrough in the planning and construction of Xiongan New Area. *Regional Economic Review, 02*, 25-32.

Wang, J. H. (2004). The adjustment of administrative divisions and the leapfrog development of urban space. *Planner,54*(5),77-79.

Wang, Y. M., Wang, Y. Q., & Zhang. K. (2008). The changes and influences of the pattern of administrative divisions of Chinese cities in the past ten years. *Economic Geography,* (2),196-200.

Wang, L. (2006). Research on the Economic Model of Urban New District Development. *Guizhou: Guizhou University*,*15*(5), 30-36.

Wang, L. L. (2018). *Evaluation and analysis of underground space resources in Lanzhou new district* (Master dissertation). Retrieved from China HowNet (Accession No. TU983.75)

Wang, H. (2003). The internal mechanism and spatial effects of the relationship between development zones and cities. *Urban Planning,* (3),20-25.

Wang, Q. (2013). *Disaster Prevention Planning Study for The High-Density Area of City Center* (Doctoral dissertation). Retrieved from China HowNet (Accession No. D630; F256.33)

Wang, R. (2009). Urbanization Response Research on Administrative Division Adjustment - Taking Jiangsu as an Example. *Urban Development Research,6*,97-101.

Wang, X., Zhou, W. & Wu, D.T. (2006). The coupling relationship between industrial function positioning and urban development strategy in new district

--- Take Beijing Haidian New District as an example. *Urban Issues, 06*, 11-15.

Wang, Z., You, B., & Wang, L. Y., (2014). Research on the optimization of the spatial structure of urban new districts based on smart growth: a case of Tianjin Binhai New District. *Areal research and development,33*(4),90-95.

Wang, J. N. & Luo, C. P. (2017). An outline of China's coordinated regional development strategy in the new era. *Reform, 12*, 52-67.

Watson, C. (1993, July). Trends in world urbanisation. In K. B. Wildey, & Wm H. Robinson (eds.), *The First International Conference on Urban Pests.* (pp.45-53). Zurich, Switzerland: Executive Committee of the International Conference on Urban Pests.

Wei, H., Wei, Q. Q., Cao, T. Y., & Zhao, J. (2009). Types, problems and development of administrative division adjustment in the process of urbanization in 2009. *Human Geography,* (6),55-58.

Woodworth, M.D., & Wallace, J.L. (2017). Seeing ghosts: Parsing China's 'ghost city'

controversy. *Urban Geography, 38*(8), 1270–1281.

Wu, F. (1996). Changes in the structure of public housing provision in urban China.*Urban Studies,33*,1601–1627.

WU, F. (1999). The 'game 'of landed-property production and capital circulation in China's transitional economy, with reference to Shanghai, *Environment and Planning A,31*,1757–1771.

WU, F. (2018). Planning centrality, market instruments: Governing Chinese urban transformation under state entrepreneurialism. *Urban Studies,55*(7),1383–1399.

WU, F. (2020, July). Emerging Cities and Urban Theories: A Chinese Perspective. In Denise Pumain (ed.), *Theories and Models of Urbanization.* Lecture Notes in Morphogenesis (pp.171-182). Springer, Berlin.

Wu, F., & Phelps, N. A. (2008). From Suburbia to Post-Suburbia in China? Aspects of the Transformation of the Beijing and Shanghai Global City Regions. *Built Environment,34*(4),464-481.

Wu, F., & Phelps, N. A. (2011). (Post)suburb an development and state entrepreneurialism in Beijing' souter suburbs. *Environment and Planning,43*,410-430.

Wu, Y.Q. (2014). Analysis of regional development strategies in ethnic areas of Guizhou from the perspective of industrial clusters. *Guizhou Ethnic Studies, 08,* 154-158.

Wu, Y. Z., & Sun, X. F. (2018). Retrospect and Prospect of China's Land Policy in the 40th Anniversary of Reform and Opening-up: The Perspective of Urbanization. *China Land Science,32*(7),7-14.

Wu, W. B. (2012). *Research on the evaluation of urban underground space resources in Suzhou* (Master dissertation). Retrieved from China HowNet (Accession No. TU984.23)

Wu, W. Y. (2014). *Urbanization and mechanism of China: A government behavior perspective* (Doctoral dissertation). Retrieved from China HowNet (Accession No. D630; F299.21)

Wu, X. Z. (2021). Study on Assessment of Urban Underground Space resources in Wuhu City. *Chinese Journal of Underground Space and Engineering, 17*(1), 9-20.

Xia, Y. (2014). Negative impact of urban gentrification on low-income aboriginal people: a case study of Nanjing. *Urban Issue,5*,92-97.

Ye, C., & Zhou, C. (2010). The theory and practice of urban new district development. *World Geographical Research,* (4),106-112.

Zargarian, R. (2017). *Exploring the Appropriateness of Urban Underground Space (UUS) for Sustainability Improvement*. (Doctoral dissertation). Retrieved from https://etheses.bham.ac.uk/id/eprint/7975/1/Zargarian17PhD.pdf

Zhan, Y. (2018). The urbanization of rural migrants and the making of urban villages in contemporary China.*UrbanStudies,55*(7):1525–1540.

Zhang, F. Z., & Wu, F. (2021). Performing the ecological fix under state entrepreneurialism: A case study of Taihu New Town, China. *Urban Studies,00*(0),1-17.

Zhang, H. P. (2019). China 70 Years of Urban-Rural Relations in China: From Segmentation to Integration. *China's rural economy,3*(0),2-18.

Zhang, J. (2007). Decentralization and Growth: China's Story.*Economics,7*(1),21-52.

Zhang, J. X., & Fan, C. L. (2002). On the adjustment of administrative divisions and the promotion of urbanization. *Urban Planning Transactions,11*(5),25-28.

Zhang, J. Y. (2016). *Research on Mutual development of Cities and Development zones* (Doctoral dissertation). Retrieved from China HowNet (Accession No. TU984.31)

Zhang, X. D., & Qian, S. (2002). The "Government Paradox" in the Process of Urbanization in China. *Journal of the National School of Administration, 5*(5), 37-41.

Zhao, D. (2014). Foreign direct investment, urbanization and Unbalanced development of the labor market. *Economist,10*,86-95.

Zhao, J. T., Zhang H. L., Du, G. Y. & Lv, X. (2015). The Development Trend and Land Use Management in the New Districts of Cities in China. *Land Resources Intelligence, 11,* 10-16

Zheng S. Q., Sun W. Z., Wu J., & Wu E. W. (2014). "Generating wealth with land and nourishing land with wealth"-Research on the investment and financing model of urban construction with Chinese characteristics. *Economic Research, 08,* 14-27.

Zhou, M., & Logan, J. R. (1996). Market transition and the commodification of housing in urban China. *International Journal of Urban and Regional Research, 20*,400–421.

Zou, W. J. (2005). A preliminary study on the design of construction scheme of urban integrated disaster mitigation service system. *Natural Disasters Journal,13*(3), 30-32.

Zhou, W. L., Hao, Q. J., & Zhou, J. J. (2007). Political economics analysis of administrative division adjustment one by one taking the Yangtze River Delta as an example. *World Economics Collection,12*(5),82-91.

Zhou, X. G., & Li, Q. (2020). Research on the evaluation system of available resources of urban underground space in the new era. *Urban and Rural Construction, 4*, 241-247.

Zhu, C. (2011). The Influence of the Process of Decentralization on the Spatial Structure and Planning of Metropolitan Areas——Based on the Investigation of Two Decentralization Models. *Urban Planning Journal,* (3),81-86.

Zhu M. J. (2018). A study on the characteristics and mechanism of population migration in "old city-new district"--Guangzhou as an example. *Urban Development Strategy, 09*, 20-29.

Zhu, M. J. & Zhou, C. S. (2012). A study on the evolution, characteristics and mechanisms of new urban area development in China since the reform and opening up. *Modern Urban Studies, 09,* 80-87.

Zhu, M. Y., & Zhou, C. S. (2013). Research progress on the development theory of urban new districts at home and abroad. *Tropical Geography,33*(3),363-372.

Zhu, X. (2002). *The theory of urban spatial concentration and decentralization.* Beijing, China Construction Industry Press.

Annex

Associated research Centers for Urban Underground Space official website, 2019. Available at: <https://www.acuus.org/index.php/what-is-acuus> [Accessed 20 August 2021]

Benesse Art Site Naoshima, 2022. Available at: https://benesse-artsite.jp/art/chichu.html [Accessed 16 January 2022]

China National Geographic Information Public Service Platform official website, 2021. Available at: https://service.tianditu.gov.cn/#/ [Accessed 18 October 2021]

China Development Zone Website,2022. Available at: www.cadz.org.cn [Accessed 5 February 2022]

Chuzhou Statistics Bureau, 2020. Available at: <http://tjj.chuzhou.gov.cn/>[Accessed 20 October 2021]

International Tunnelling and Underground Space Association official website, 2015. Available at: https://about.ita-aites.org/publications [Accessed 20 August 2021]

Chuzhou Nanqiao District People's Government Official Website, 2021. <http://www.cznq.gov.cn/gkxx/nqgk/index.html> [Accessed 20 August 2021]

National Bureau of Statistic, 2021. Available at: <http://www.stats.gov.cn/> [Accessed 26 August 2021]

China National Geographic Information Public Service Platform official website, 2021. Available at:https://service.tianditu.gov.cn/#/ [Accessed 30 August 2021]

Gooood Design, 2022. Available at: https://www.gooood.cn/rain-garden-ups.htm [Accessed 23 January 2022]

Jiangsu Beautiful Countryside, 2022. Available at: https://www.bing.com/images/search?q=%e6%b1%9f%e8%8b%8f%e7%9c%81%e4%b9%a1%e6%9d%91%e6%97%85%e6%b8%b8&form=HDRSC2&first=1&tsc=ImageHoverTitle [Accessed 5 February 2022]

Jiangsu Provincial People's Government Official Website, 2022. Available at:

www.jiangsu.gov.cn [Accessed 5 February 2022]

Kyoto Train Station, 2022. Available at: https://www.sohu.com/a/196098950_211987 [Accessed 16 January 2022]

Los Angeles Central Library official website, 2022. Available at: https://www.lapl.org/branches/central-library/departments/popular-library/map [Accessed 21 January 2022]

Nanjing Jiangbei New District Management Committee official website,2022. Available at: http://www.assc.org.cn/cases/9 [Accessed 16 January 2022]

Nanjing University BaiduBaike, 2022. Available at: https://baike.baidu.com/item/%E5%8D%97%E4%BA%AC%E5%A4%A7%E5%AD%A6%E4%BB%99%E6%9E%97%E6%A0%A1%E5%8C%BA [Accessed 16 January 2022]

People's Daily official website, 2022. Available at: http://paper.people.com.cn/rmrb/html/2022-02/15/nbs.D110000renmrb_01.htm [Accessed 5 February 2022]

Seismic Active Fault Survey Data Center, 2022. Available at: http://www.activefault-datacenter.cn/ [Accessed 16 January 2022]

Shaanxi Provincial People's Government Official Website, 2022. Available at: www.shaanxi.gov.cn [Accessed 5 February 2022]

Tenjin Underground Street official website, 2022. Available at: https://www.tenchika.com/ [Accessed 16 January 2022]

Travel Qunar, 2022. Available at: http://travel.qunar.com/p-pl4905897 [Accessed 21 January 2022]

Yaesu Mall,2022. Available at: https:// Yaesu.mall /a/196098950_211987 [Accessed 16 January 2022]

Zhihu Discuss,2022. Available at: https://zhuanlan.zhihu.com/p/63398292 [Accessed 5 February 2022]