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MANAGEMENT OF URBAN UNDERGROUND SPACE DEVELOPMENT IN SHANGHAI: EXPERIENCE AND CHALLENGES

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Abstract: Since the concept of urban underground space (UUS) utilization was first written into the Shanghai Master Plan (1999-2020), there has been a significant surge in UUS development, with the total area reaching 155 million m^2 by the end of 2023. Establishing a robust management system to promote cooperation between public and private sectors and to achieve interdepartmental collaboration is crucial for ensuring high efficiency of UUS development. This paper systematically analyzed the evolution of UUS management in Shanghai over the past three decades through expert consultations, field investigations and government document analysis. The results indicated that the legislation pathway of 'specialized first, comprehensive later' and 'policies first, regulations later' has shaped the current '1+N+N' regulation framework in Shanghai, providing full coverage of UUS scopes and utilization processes. Furthermore, clarifying municipal and district-level competent authorities for UUS utilization was crucial during the rapid development phase of UUS. Another feature of UUS management in Shanghai was the flexible adjustment of competent authorities in response to urban development demands. Empowering UUS planning with statutory effectiveness standardized UUS development by private sectors. The government-dominated and market-driven mode of UUS construction achieved a win-win situation for the government, the public and developers. As Shanghai has entered a new urbanization phase characterized by urban renewal, the existing UUS management faces new challenges. How to improve the local comprehensive statute for UUS utilization, how to optimize incentive policies, how to construct an effective interdepartmental coordination platform based on the new competent authority, how to establish UUS management mechanisms applicable to urban renewal and how to supplement unit level plans to bridge the gap between UUS master plans and detailed plans, remained critical issues to be addressed. This paper aims to provide insights into UUS management for other high-density metropolitan cities.

Keywords: urban underground space, legal system, management mechanism, planning system, Shanghai

1. INTRODUCTION

Development of urban underground space (UUS) is a critical strategy to promote urban sustainability and resilience in metropolis **(Bobylev et al., 2023; Zhang et al., 2024)**. Although it has become a consensus in Chinese cities, a top-down management system covering the entire process of UUS utilization has not yet been established at the national level **(Xu & Zhu, 2013)**. A robust management system established by the government is essential for sustainable and highly efficient UUS utilization. Over the past 30 years, many Chinese cities have conducted legislative and management practices for UUS management in accordance with their urban development demands. Among them, Shanghai is a representative city, renowned for its high performance of UUS development and its systematic UUS management framework **(Ma & Peng, 2023)**. Research on UUS management in Shanghai can provide valuable insights for establishment of top-down management systems at the national level and in other Chinese cities.

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Prior studies usually focused on the legislation of UUS property rights. **Zaini et al. (2017)** analyzed the content related to UUS ownership and the bundle of rights and depth in current laws of Malaysia and compared these with Japan, Finland, and Hong Kong to propose optimization suggestions. **Mária et al. (2021)** explored UUS governance in the European Union from a space resource perspective. **Zhang et al (2017)** highlighted that property rights played a crucial role in improving UUS legislative systems and proposed legislative suggestions based on public goods theory. Other scholars also argued for the urgent need to construct a top-down unified UUS legal framework to achieve comprehensive control over UUS development in China **(Zhang et al., 2020; Peng et al., 2024)**. On the other hand, construction of planning systems is equally important to sustainable UUS utilization. **Yuan et al. (2019)** proposed the importance of strengthening the coordination mechanism for detailed planning based on the comparison between UUS planning systems in China and Japan. **Von der Tann et al. (2020)** discussed the principles of systems thinking and presented a perspective on what elements should be included in systemic approaches for planning and management of UUS. **Zhao and Yuan (2024)** suggested that China should integrate UUS planning into the territorial space planning system to protect UUS resources during its development. Additionally, **Gui (2018)** analyzed the UUS administrative management system in Beijing and pointed out that it lacked a unified competent authority and interdepartmental coordination mechanisms. In summary, scholars have researched UUS management issues from the following three aspects: legal systems, management mechanisms and planning systems. National level studies were conducted with many valuable suggestions. However, Chinese cities vary significantly in their demands and levels of UUS development. National level studies are usually too macroscopic to directly guide the construction of UUS management systems in specific cities. Therefore, it is still necessary to select specific cities or regions for in-depth and comprehensive studies.

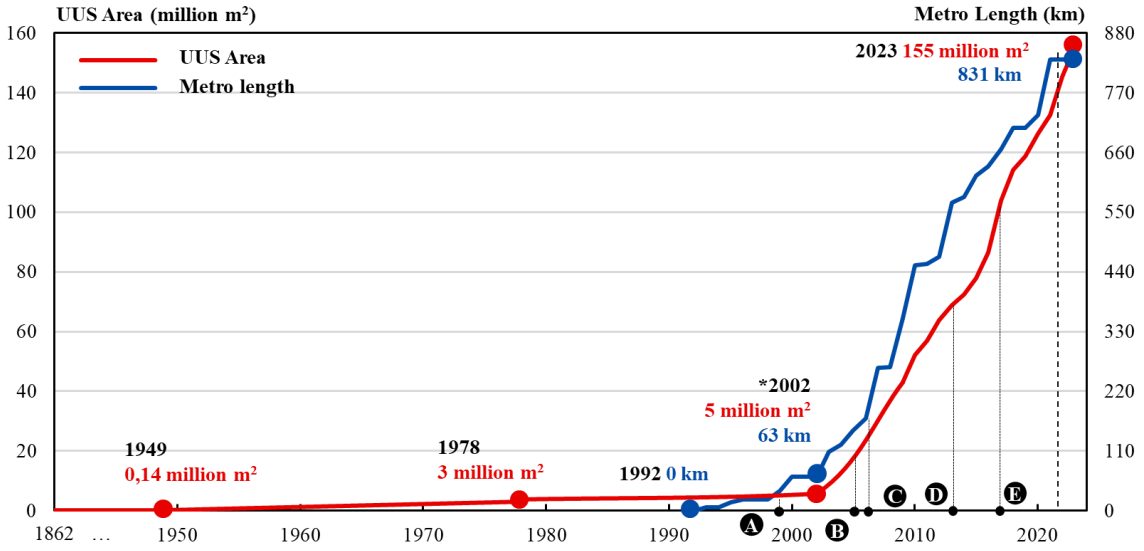
This paper aims to thoroughly analyze the evolution of UUS development management in Shanghai over the past 30 years and summarize the experience and challenges of management systems from the perspective of legal systems, management mechanisms and planning systems. In terms of the methodology, we conducted two expert consultations (including 16 experts from universities, government departments, planning and design institutes, construction enterprises in Shanghai) and 13 field investigations (in 13 UUS management related public sectors) from November 2023 to August 2024. Government policies and planning documents related to UUS utilization were also collected and analyzed. The remainder of this paper is structured as follows. In **Section 2**, we briefly review the current situation of UUS utilization in Shanghai. **Section 3** summarizes the experience of UUS management from three aspects. **Section 4** proposes five challenges faced by the government in improving its management performance in the new urbanization stage of urban renewal. Concluding remarks on this research are finally provided in **Section 5**.

2. CURRENT SITUATION OF UUS UTILIZATION IN SHANGHAI

Utilization of UUS in Shanghai dates back to the 19th century, when the buried pipelines (1862) and underground prisons of Louza Police Station (1888) were constructed in the International Settlement **(Huang, 2015)**. The early development was closely related to the beginning of modern urbanization. **Figure 1** illustrates the development trend of UUS from 1862 to the present **(Shanghai Municipal Commission of Housing and Urban-Rural Development, 2023)**. Owing to the geological conditions, construction technology, economic development and UUS cognition, the utilization of UUS in Shanghai has experienced a long period of slow development in the 20th century, followed by the explosive growth thereafter. Its dominant ideology has also evolved through several stages: high-rise building and buried pipelines (before 1949), civil air defense projects (1949–1978), hybrid mixing of peacetime and wartime functions (1978–1999) and comprehensive functions (from 1999 to the present) **(Qiao & Peng, 2016)**. In 2002, Shanghai was awarded the hosting rights for the 2010 World Expo, marking the beginning of a period of rapid urbanization in the city. UUS amount surged alongside the construction of the municipality-wide metro system and numerous land development projects in the main city. The total UUS area reached 155 million m^2 in 2023. However, with the gradual transition of urbanization development modes into the urban renewal stage, the annual growth area of UUS exhibited a fluctuating downward trend since 2017, decreasing to below 10 million m^2 in 2023. Newly added UUS was mainly located in urban renewal areas of the city center, peripheral sub-centers and the five developing new towns in the suburbs.

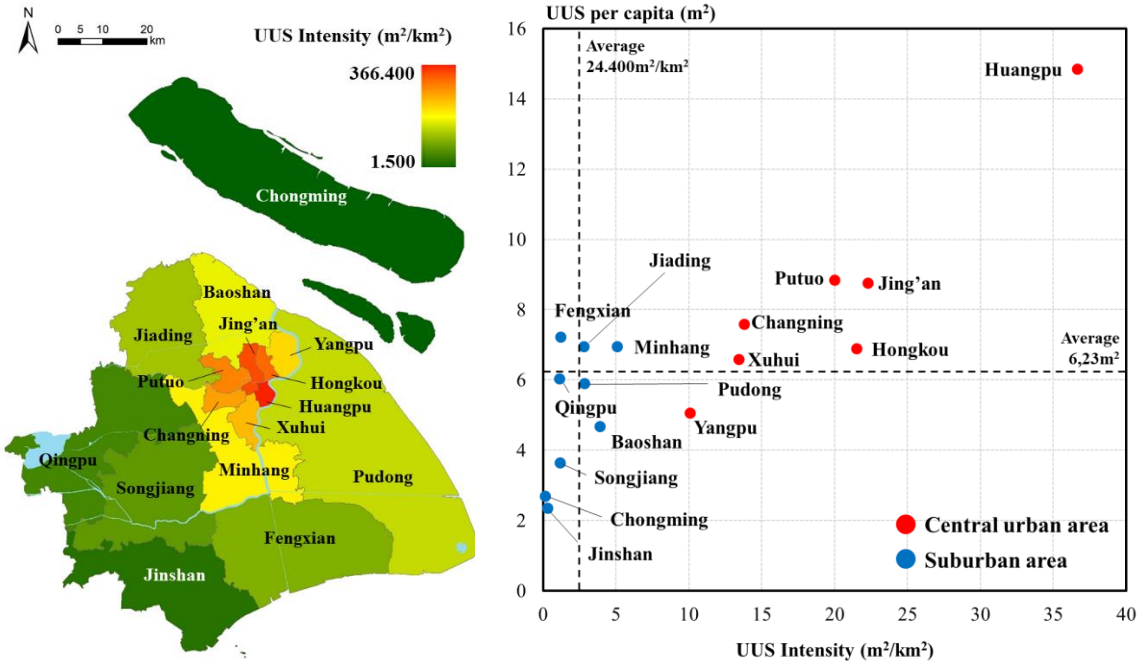
Average UUS intensity for the municipality-wide area of Shanghai reached 24.400 m^2/km^2 in 2023. **Figure 2(a)** reveals the intensity distribution across the 16 districts of the city in 2023, showing a gradual decrease from the city center to the suburbs. Huangpu District had the highest development intensity, while Chongming District had the lowest. **Figure 2(b)** shows the comparison of UUS per capita and UUS intensity of UUS in Shanghai. Huangpu District achieved both the highest UUS per capita and intensity, indicating its highest efficiency of UUS utilization, compared with other areas. Qingpu, Songjiang, Chongming and Jinshan were located in the outer suburbs, where UUS demands were lower than that in other districts, resulting in low values for both indicators. Furthermore, districts of Yangpu, Pudong and Baoshan had relatively high UUS intensity, but their indicators of

UUS per capita were low. It indicated a possible undersupply of UUS, especially in Yangpu, which was the only one located in central urban area among the three districts. On the other hand, Fengxian obtained a high values of UUS per capita with low UUS intensity. Rapid construction of Fengxian New City increased its total UUS area. However, the discrepancy between the two indicators also suggested the possibility of an oversupply of UUS.



* Obtained hosting rights for 2010 World Expo in 2002
A UUS planning requirements first incorporated into the urban master plan in 1999
B First UUS master plan in Shanghai issued in 2005
C UUS Management Joint Conference System (UMJCS) established in 2006
D Statutes on the Planning and Construction of Underground Space in Shanghai (SPCUSS) issued in 2013
E UUS planning requirements incorporated into the latest urban master plan in 2017

Figure 1. *UUS and urban rail transit development in Shanghai (Data source: **Shanghai Municipal Commission of Housing and Urban-Rural Development, 2023**)*



(a) UUS Intensity *(b) Comparison of UUS per capita and UUS intensity*

Figure 2. *UUS development status of 16 districts in Shanghai in 2023 (Data source: **Shanghai Municipal Commission of Housing and Urban-Rural Development, 2023**)*

Figure 3 compares the growth rates (2013–2023) and area proportions of different UUS functions in Shanghai in 2023. There is an unbalanced distribution of UUS functions. Underground transportation (No. 1-5) and municipal infrastructure (No.6), particularly car parks, accounted for 77,78% of the total UUS area and obtained high growth rates. This was consistent with the analysis results from 2013 **(Qiao & Peng, 2016)** and indicated that UUS development in Shanghai still primarily focused on addressing urban traffic problems and serving as municipal facilities in Shanghai. Underground service facilities (No. 9-17) accounted for 4,64% of the total UUS area, of which shopping was the dominant function with an extremely high growth rate of 175,42%. Land developers increasingly focused on the economic value of UUS development, especially in metro-led areas, to achieve excess profit returns **(Shi & Zhou, 2017; Ma et al., 2024)**. On the other hand, abandoned or unused space (No.19) obtained a high proportion of 8,15%. Although its growth rate was lower than the average, the phenomenon of low-efficiency utilization of UUS resources still existed.

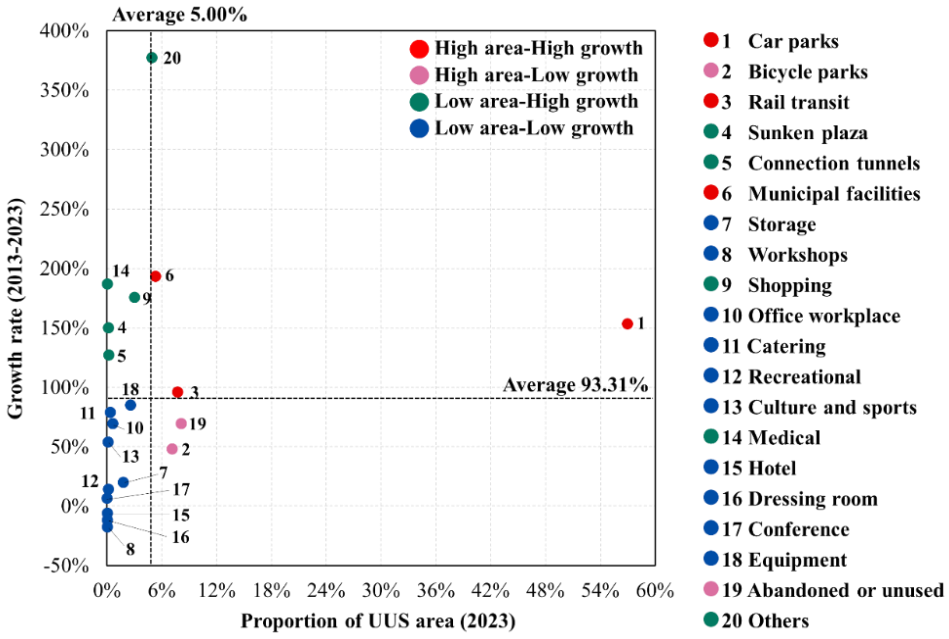


Figure 3. *Comparison of growth rate (2013-2023) and area proportion of different UUS functions in Shanghai (Data source: **Shanghai Municipal Commission of Housing and Urban-Rural Development, 2023**)*

3. EXPERIENCE OF UUS MANAGEMENT

3.1. Legal system

Shanghai began integrating UUS management requirements into existing regulations and established UUS a legal system in the 1990s. By 2025, Shanghai has developed a systematic '1+N+N' UUS legal framework, with a local comprehensive statute on UUS serving as the core, supplemented and supported by several local specialized statutes on specific underground facilities and a range of related regulations and policies (e.g., regulations, provisions, measures, opinions, rules), as illustrated in **Figure 4**.

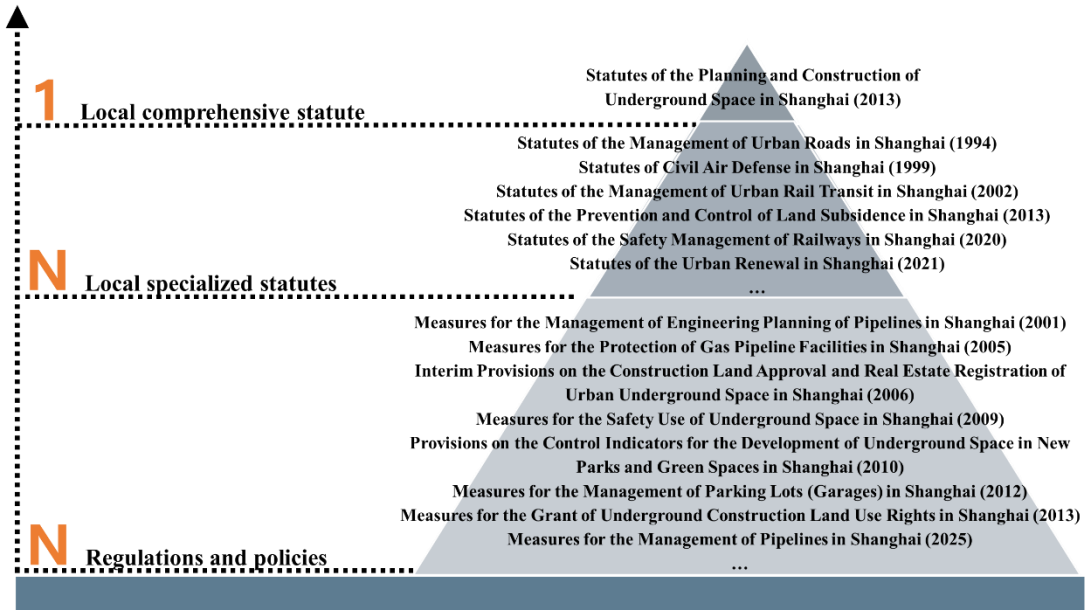


Figure 4. *UUS Legal systems in Shanghai*

(1) Successful legislation pathway of 'Specialized first, Comprehensive later' and 'Policies first, Statutes later'

Similar to the UUS legislation process of Japan **(Liu & Shen, 2007)**, construction of Shanghai's UUS legal system also followed a pathway of 'Specialized first, Comprehensive later' and 'Policies first, Statutes later'. In the 1990s, underground roads, metro systems, civil air defense projects, underground pipelines and underground parking space were among the earliest constructed underground facilities. Public sectors accumulated extensive experience in managing these specialized UUS. Subsequently, before 2013, the government successively promulgated regulations and management measures for urban roads (1994), civil air defense projects (1999), urban pipelines (2001), metro systems (2002), gas pipelines (2005) and parking lots (2012). These measures standardized the space management of urban transportation and municipal infrastructure, including their underground components. On the other hand, local statutes usually have higher legal effects compared with regulations and policies issued by local governments **(Zhang et al., 2020)**. To test the rationality of management requirements and accumulate experience for local legislation, the Shanghai Government formulated several measures on planning and safety use of UUS and its property ownership registration from 2006 to 2010. Establishment and revision of the above-mentioned specialized regulations and diverse UUS-related regulations and policies provided the basis for the legislation of the local comprehensive statute on UUS, namely the Statutes on the Planning and Construction of Underground Space in Shanghai (SPCUSS) in 2013. It was enacted by the Standing Committees of Shanghai People's Congress, representing a legal force second only to the Constitution and national laws.

(2) Full coverage of UUS scopes and utilization process in the municipality-wide area

Taking SPCUSS as an example, the definition of UUS was 'the space below the surface within the administrative boundary of this city'. It encompassed both artificially constructed space and undeveloped UUS resources. The full coverage of UUS scopes reflected the principle that the Shanghai Government constructed the UUS legal system from the perspective of natural resource protection and orderly utilization. Therefore, in addition to management regulations on specific underground facilities, the UUS legal system in Shanghai also included policies related to ground subsidence and geothermal resource development. Moreover, the management systems also covered the entire process of UUS planning, construction and operation. They provided detailed regulations or descriptions for land use, real estate registration and development incentives for private sectors related to UUS. This holistic approach ensured that all aspects of UUS utilization were governed by clear and comprehensive legal frameworks, promoting sustainable and efficient development.

3.2. Management mechanisms

Shanghai was one of the earliest cities in China to initiate the construction of a comprehensive UUS management model, clarifying the competent authorities for the entire process of UUS utilization and establishing systematic management mechanisms. In July 2006, the Shanghai Government established the UUS Management Joint Conference System (UMJCS), a coordination mechanism involving UUS-related public departments and one

state-owned enterprise (Shanghai Metro Company) responsible for comprehensive management of the major issues of entire process of UUS development, including planning, construction and operation. The Shanghai Municipal Bureau of Civil Affairs (SMBCA) was in charge of the UMJCS, which was actually appointed as the municipal competent authority for UUS development in the city. From 2006 to 2009, the 16 districts of Shanghai also established district-level UMJCSs, with the district civil affairs offices taking charge of UUS development. In September 2014, following a functional adjustment in public departments, the current Shanghai Municipal Bureau of Planning and Natural Resources (SMBPNR) was appointed as the competent authority for UUS development according to the SPCUSS. Furthermore, since 2006, Shanghai has successively established several specialized management platforms or systems targeting UUS utilization, including the Shanghai UUS Information Infrastructure Platform (2006), UUS Expert Consultation Group (2007), UUS Safety Management Mechanism (2009) and Professional Grid-based Management Mechanism for UUS (2010).

(1) Clarifying municipal and district-level competent authorities for UUS utilization

Given the multiple functions of UUS, its administrative and approval management in Shanghai involved as many as 20 municipal departments currently as shown in **Table 1**. Among them, the SMBPNR, Shanghai Municipal Commission of Housing and Urban-Rural Development (SMCHURD) and SMBCA were the three most important departments. They were respectively responsible for the planning and land use approval of UUS, construction management, and the entire process of approval and management of civil air defense projects. Clarifying UUS competent authorities has established a mature top-down management system **(Gui, 2018)**. Combined with the UMJCS, the mechanism has effectively addressed issues that required interdepartmental coordination in UUS utilization (e.g., compilation of UUS plans, major underground public space or complex projects development management), unmanaged issues under the traditional framework (e.g., safety inspections of existing UUS), and new challenges faced in urban construction regarding UUS development (e.g., establishment of underground land use rights).

Table 1. *Current UUS-related municipal government departments in Shanghai*

Municipal departments	In UMJCS?		Management stages*			
	Yes	No	CA	P	C	O
Shanghai Municipal Bureau of Planning and Natural Resources	●		●	●	●	●
Shanghai Municipal Commission of Housing and Urban-Rural Development	●				●	●
Shanghai Municipal Bureau of Civil Affairs	●			●	●	●
Shanghai Municipal Development & Reform Commission	●			●		●
Shanghai State-owned Assets Supervision and Administration Commission		●				●
Shanghai Municipal Commission of Economy and Informatization	●			●		●
Shanghai Municipal Bureau of Public Security	●					●
Shanghai Municipal Bureau of Finance		●			●	●
Shanghai Municipal Bureau of Ecology and Environment		●		●		●
Shanghai Municipal Commission of Transport	●			●	●	●
Shanghai Municipal Bureau of Water Resources	●			●	●	●
Shanghai Municipal Administration of Culture and Tourism		●			●	●
Shanghai Municipal Commission of Health	●					●
Shanghai Municipal Bureau of Emergency Management	●			●	●	●
Shanghai Municipal Bureau of Fire and Rescue	●				●	●
Shanghai Municipal Administration for Market Regulation	●					●
Shanghai Landscaping & City Appearance Administrative Bureau	●			●	●	
Shanghai Urban Management and Law Enforcement Bureau		●				●
Shanghai Municipal Bureau of Housing Administration	●					●
Shanghai Municipal Bureau of Data		●				●

* Note: CA, competent authority of UUS management; P, planning; C, construction; O, operation.

(2) Flexibly adjusted competent authorities based on to urban development demands

Shanghai's UUS management mechanism was not constructed overnight. The mechanism evolution was highly related to UUS development demands, ensuring that the management could continuously meet the requirements of urban development. Before 2006, UUS development management was characterized by a parallel management mode, in which each department performed its own duties independently. During this period, UUS was mainly composed of civil air defense projects (managed by the SMBCA) with few comprehensive functions, making the traditional mode still effective **(Qiao & Peng, 2016)**. From 2002 to 2006, Shanghai's urbanization rate jumped from 76,4% to 85,8%, with an average annual population increase of 3,3%. Urban space resources were in short supply. Meanwhile, to host the 2010 World Expo, a series of urban renewal and new city construction projects were conducted. UUS scale increased rapidly and the demand for comprehensive UUS development in the core areas gradually emerged. Then the parallel mode was no longer capable of coping with the increasing

complexity and interconnectivity of UUS development. Due to the inertia of traditional UUS cognition and the established jurisdiction of government departments, the SMBCA was appointed as the competent authority for UUS utilization in 2006. Over the following eight years, UUS functions became increasingly comprehensive and the proportion of civil air defense space gradually decreased. Limited by its departmental functions, the SMBCA was no longer suitable as the chief authority. Since spatial planning has become the primary link in land transfer and development and the city was still in the stage of rapid urbanization. 'Planning-led' has become a common consensus for UUS utilization and protection. Then the UUS management system led by the SMBPNR was ultimately established in 2014.

3.3. Planning system

Construction of a comprehensive planning system is fundamental to regulating sustainable utilization of UUS resources **(Yuan et al., 2019; Zhang et al., 2022)**. After multiple changes, **Figure 5** reveals the current UUS planning system. It comprised two planning levels, correlating with the top-down territorial space planning system of Shanghai **(Zhao & Yuan, 2024)**. The master level of UUS planning focused on the protection of UUS resources and control of space utilization. In contrast, the detailed level was oriented towards land development, emphasizing the functional positioning, space layout of different underground facilities and UUS interconnectivity requirements. It served as the basis for planning management and land leasing of UUS development.

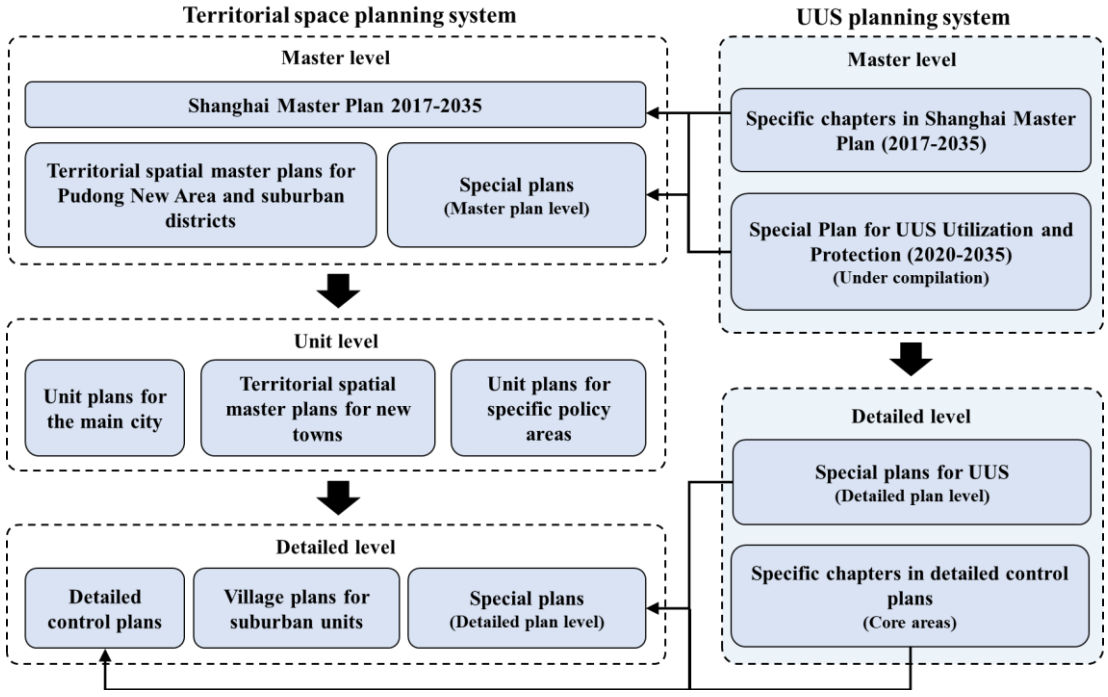
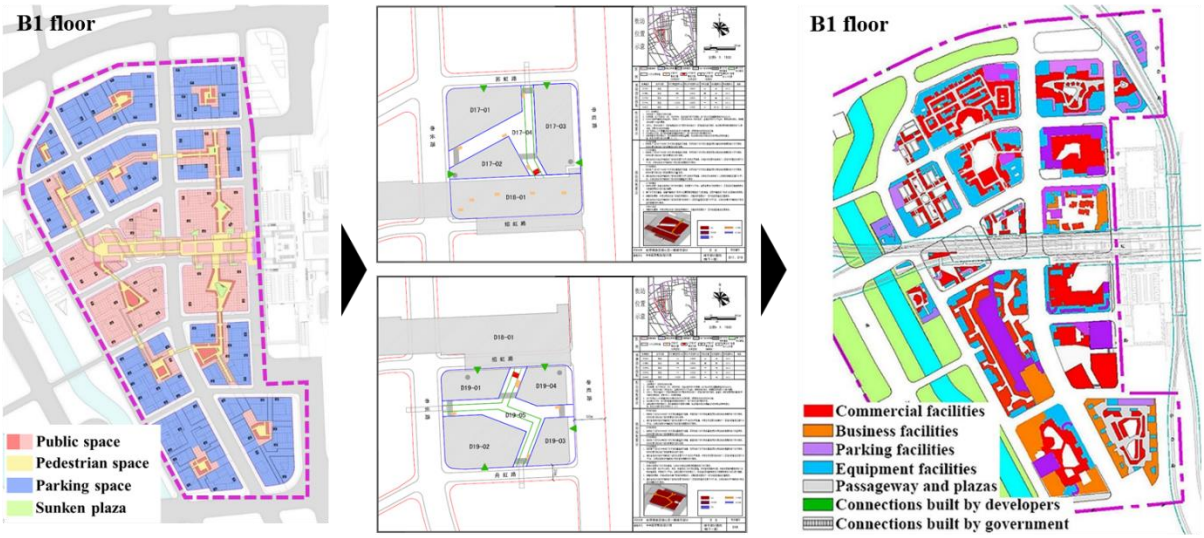


Figure 5. *Current UUS planning system and territorial space planning system in Shanghai*

(1) UUS planning empowering statutory planning effectiveness

Unlike Helsinki's Underground Master Plan **(Vähäaho, 2016)**, UUS master plans and detailed plans were merely special plans with no statutory planning effectiveness according to the Urban and Rural Planning Law in China. Previous studies also indicated that UUS planning failed to regulate UUS utilization due to the lack of legal force **(Peng et al., 2019)**. To address the problem within the existing national legal framework, UUS plans have been consistently integrated into statutory planning systems for aboveground space in Shanghai. At the master level, planning requirements for UUS were incorporated as specific chapters into the Shanghai Master Plan (1999-2020) and the Shanghai Master Plan (2017-2035). Although the two UUS master plans were separately compiled in 2005 and 2020 under the guidance of the two urban master plans, SPCUSS (Article 9) required that the planning outcomes should be integrated into the urban master plan, thereby empowering them the statutory planning effectiveness. At the detailed level, traditional urban detailed plans only involved Regulatory Universal Plans (RUPs) to propose basic requirements such as land use, floor area ratios and density before 2010. An innovative approach was adopted to incorporate the separately compiled UUS detailed plans into traditional detailed plans in the form of Regulatory Additional Plans (RAPs) during the planning compilation of Hongqiao Central Business

District (CBD) in 2010 as shown in **Figure 6**. This effectively imposed the statutory planning effectiveness on UUS detailed plans to standard land development by private sectors **(Shanghai Planning and Land Resources Management Bureau et al., 2020; Peng et al., 2020)**. This approach was retained and normalized as a planning technical requirement in the Shanghai Technical Guidelines for Control Detailed Planning (STGCDP) in 2011: Regardless of whether a separate UUS detailed plan is compiled, it is mandatory to compile RAPs with UUS planning indicators (e.g., construction area of UUS, depth and floors, main functions, UUS scale, connecting passages and sunken plazas) for detailed plans of public activity centers, historical and cultural districts, important waterfront areas, scenic areas and transportation hub areas **(Shanghai Planning and Land Resources Management Bureau et al., 2020)**.



(a) UUS Detailed Plans *(b) Regulatory Additional Plans* *(c) Current UUS layout*

Figure 6. *Planning and current development layout for UUS in Shanghai Hongqiao CBD (Data source: **Peng et al., 2020**)*

(2) Government-dominated and market-driven UUS development mode

Based on public land ownership, detailed plans served as the basis for public sectors to regulate land development. According to the data from SMCHURD **(Shanghai Municipal Commission of Housing and Urban-Rural Development, 2023)**, 85,8% of UUS consisted of building basements, which were essentially constructed through land development driven by private sectors. Relying on the UUS planning system with statutory planning effectiveness, municipal departments could exercise macroscopical control over state-owned three-dimensional land resources, obtaining revenue from land leasing to serve for other public service and ensuring public interests. Meanwhile, private sectors flexibly engaged in land development within the requirements of the detailed plans to achieve excess profits. Ultimately, this government-dominated and market-driven UUS development mode enabled a win-win situation for the government, the public and developers.

4. CHALLENGES OF UUS MANAGEMENT

Currently, urbanization development stages in Shanghai have shifted from rapid urban expansion to urban renewal. Although the well-developed legal system, management mechanisms and planning system have supported the rapid construction of UUS over the past 25 years, several challenges still remain.

4.1. Incomplete local comprehensive statute of SPCUSS

The SPCUSS is regarded as the local comprehensive statute with the highest legal force for UUS utilization in Shanghai. It has undergone two revisions in 2018 and 2020 after its initial release in 2013. However, the current SPCUSS only covers the management and penalty provisions of UUS planning, construction, land use and property rights, lacking provisions for UUS usage and operation. Relevant management requirements are scattered across various specialized management statutes or government regulations. Compared with other 68 Chinese cities that have already issued their local comprehensive statutes, only 10 cities do not include provisions for UUS usage

management. As Shanghai has entered a new urbanization stage of urban renewal, safety use and sustainable operation of existing UUS become more and more important to public administration of the government. With the accumulation of management experiences over the past 12 years, it is high time to supplement the corresponding provisions so as to make the SPCUSS a truly comprehensive local statute covering the entire process of UUS utilization.

4.2. Lack of attractive and implementable incentive policies for UUS development

Incentive policies for UUS development in Shanghai include floor area ratio (FAR) bonuses and reductions in grant fees of UUS land use rights targeting the construction of underground public facilities or public space as tabulated in **Table 2**. However, these provisions are scattered across different government documents compiled at various times, without a clear definition of the UUS eligible for the incentives. Furthermore, attractiveness of the incentive policies is not as high as that of other metropolis. For example, the Provisions on the Grant of Underground Construction Land Use Rights in Shanghai (2023) did not clearly define the eligible underground public passages for reductions of grant fees. In contrast, the similar provisions also occurred in the Several Opinions on Improving the Management of State-owned Land Supply by Several Opinions on Improving the Management of State-owned Land Supply (2018) issued by the Shenzhen government, by which the eligible passage should be open to the public for 24 hours per day with the main function of interconnection between two buildings. Additionally, an additional area bonus of up to 20% of the passage area was offered for commercial uses, effectively stimulating developers' enthusiasm. Similarly, the Urban Redevelopment Authority of Singapore also proposed that the construction of underground public passages could be excluded from FAR calculations, increase activity-generating use space, and provide cash grants **(Urban Redevelopment Authority, 2021)**.

Table 2. *Currently effective incentive policies for UUS development in Shanghai*

Types*	Incentive policies	Contents
FB	Technical Provisions on Urban Planning Management in Shanghai (Land Use and Building Management)-Article 20 (2010)	Provision of open space for the public can be rewarded with an area bonus of 1,0 or 1,5 times of the area in the main city
FB	Shanghai Technical Guidelines for Control Detailed Planning-Article 13.4 (2016)	An increase in building area of up to 15% is allowed due to the addition of community public welfare facilities, public parking space, public space on the ground or in the buildings
FB	Provisions on Planning Management of Building Area Calculation in Shanghai-Article 5 (2021)	Basements meeting requirements not included in floor area ratio calculation
FB	Implementation Details of Land Use for Urban Renewal Planning in Shanghai-Article 7 (2022)	Provision of new public space or public facilities can be rewarded with an additional commercial space area ranging from 0,5 to 2,0 times of the area
LE	Provisions on the Grant of Underground Construction Land Use Rights in Shanghai-Article 9 (2023)	No setting UUS land use rights and exemption the grant fees for underground public passages and municipal facilities for regional service developed by planning

* Note: FB, FAR bonuses; LE, exemption for grant fees of UUS land use rights.

4.3. Readjustment of the UUS competent authority and reconstruction of an interdepartmental coordination platform for UUS utilization

Although the SPCUSS has nominally appointed the planning department as the competent authority for UUS development, there is no dedicated or explicitly designated sector in the department responsible for this task. Furthermore, while the management mechanism based on planning-led principles is quite applicable to the stage of explosive growth of UUS, it may be less suitable for the urban renewal phase. In this stage, it is more important for high-quality usage management of existing UUS to promote higher efficiency of UUS utilization. Therefore, the department in charge of urban construction and operation management may be more appropriate to be appointed as the UUS competent authority.

On the other hand, the main scope of the UMJCS has been restricted to UUS safety management since 2014, operated by the SMCHURD. It implies that Shanghai has no longer an interdepartmental coordination and management mechanism for UUS development since 2014. In terms of UUS statistical data, both the planning and construction authorities have established databases within their respective jurisdictions. However, there is a lack of data-sharing mechanism between them and exists an extremely large difference in data volume. Moreover, issues related to the reuse of idle UUS may involve different government departments with ownership change

approval, commercial operation approval, fire safety approval and other administrative management procedures. The absence of an interdepartmental coordination platform makes it difficult to establish a systematic mechanism to promote the high efficiency utilization of existing underground facilities. A new interdepartmental coordination platform is still necessary for UUS utilization during the urban renewal stage. Moreover, even the initially established UMJCS in 2006 still lacked some UUS-related public sectors and state-owned companies (e.g., underground pipeline companies), which should be incorporated in the construction of the new platform.

4.4. No specific management mechanisms for UUS utilization during urban renewal

UUS utilization during urban renewal encompasses both the renovation of existing UUS and newly-built UUS in existing built-up areas **(Cui et al., 2021)**. For the renovation of existing UUS, the Provisions on the Grant of Underground Construction Land Use Rights in Shanghai (2023) proposed that grant fees of UUS land use rights should be determined based on the actual UUS functions and scale. The provisions also regulated the procedures for ownership registration of both existing and newly-added UUS. However, they fail to address the problems of the changes in ownership due to the adjustments of inner space functions in the ownership registered UUS, especially when commercial space is repurposed for public functions. There are no clear procedures or mechanisms for refunding UUS land use rights and their grant fees in such situations. Moreover, no policies have been introduced for the reuse of idle UUS. In contrast, Beijing has established an interdepartmental coordination mechanism to promote this issue, as stipulated in the Guiding Opinions on Using Underground Space to Supplement and Improve Convenient Commercial Service Facilities (2018).

On the other hand, to increase space resources for allocation of parking facilities and other public facilities, additional basements are newly built under existing surface buildings, especially in historical and cultural districts and old residential areas. However, so far there has been no systematic management system and regulatory standard to regulate such UUS construction. Additionally, since the promulgation of the Property Law in 2007, land use rights have been extended to three-dimensional space **(Zhang et al., 2017)**. The Provisions on the Grant of Underground Construction Land Use Rights in Shanghai (2023) also proposed an explicit vertical range of UUS land use rights, defining it as the outer periphery of the underground buildings and structures as shown in **Figure 7**. It is quite different from the definitions in Singapore, Helsinki and Tokyo, which are all based on surface land ownership boundaries **(Vähäaho, 2016; Zhou & Zhao, 2016; Zaini et al., 2017)**. Therefore, the remaining underground space within the land use scope that has not established UUS land use rights can theoretically still be granted. Nevertheless, the current policies have not proposed the principles and requirements that should be followed. Moreover, the potential demands for such UUS also pose challenges to the traditional two-dimensional cadastral management system, calling for the establishment of three-dimensional cadaster systems **(Qiao & Peng, 2023)**.

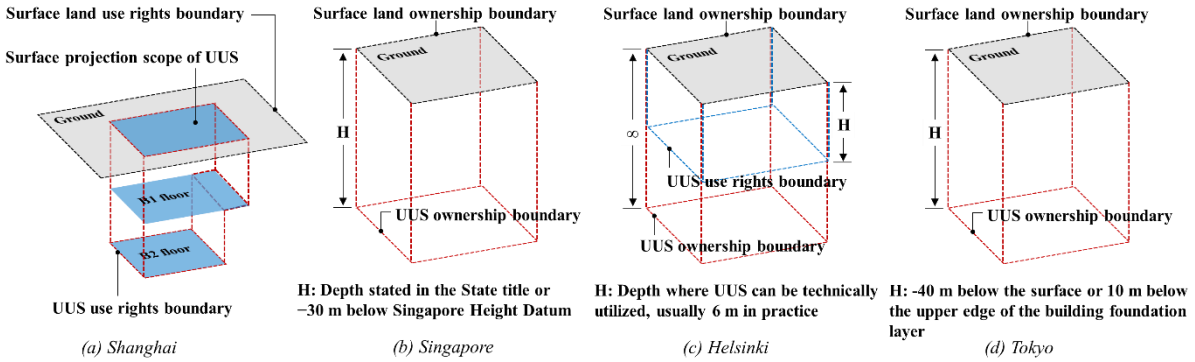


Figure 7. *Comparison of UUS land use rights or ownership boundaries in Shanghai, Singapore, Helsinki and Tokyo*

4.5. Absence of unit level UUS planning

Shanghai's two-level UUS planning system creates a disconnection between the planning requirements at the master level and detailed level. On one hand, some of the UUS requirements at master level plans are not implementable **(Wu & Zhao, 2021)**. For example, the Shanghai Master Plan (2017-2035) proposed that the underground proportion of newly built rail transit and municipal facilities (including substations, drainage pump stations and waste transfer stations) in the main city and five new towns should reach 100% by 2035. However, due to the lack of unit level plans to refine the specific areas and feasibility conditions for implementation of the requirement, this requirement is often neglected during the compilation of detailed plans. Meanwhile, the absence of unit level UUS planning also violates Article 9 of the SPCUSS. On the other hand, UUS planning requirements

at master levels do not provide detailed regulations on UUS connectivity, UUS development in public lands and layout of underground public facilities, which are the most important planning contents in RAPs at detailed levels. Due to the absence of unit level UUS planning, except for the five new towns (as they are regulated by Shanghai New Town Planning and Implementation Guideline issued in 2021), there is no explicit planning basis for UUS development while compiling detailed plans in Shanghai. Furthermore, in urban areas outside the five key areas specified in the STGCDP, RAPs with UUS development regulations are not mandatorily required, implying a lack of effectively government control over UUS utilization in these areas.

5. CONCLUSION

Shanghai is a representative city of UUS utilization in China, not only due to its large development scale and diverse functions but also because of its systematic management framework. This paper reviewed the evolution of Shanghai's UUS legal system, management mechanisms and planning system over the past 30 years. Considering the current urban renewal demands in Shanghai, this paper also identified the challenges faced by the existing UUS management systems. The findings can provide insights for optimization of UUS management systems in other Chinese cities and establishment of a top-down management system at the national level. The main contributions of this study can be summarized as follows.

(1) The successful legislative pathway of 'Specialized first, Comprehensive later' and 'Policies first, Statutes later' has shaped the '1+N+N' legal system for UUS management in Shanghai. Various government regulations and policies have achieved effective control over all UUS fields (including underground structures and unused space resources) and the entire process of UUS development. However, as the foundation and core of the regulatory system, the SPCUSS has not yet involved provisions for UUS usage management, failing to become a truly comprehensive local statute. Moreover, the incentive policies for UUS development lack sufficient attractiveness and feasibility, making it difficult to motivate private sectors to actively engage in UUS development.

(2) The case study in Shanghai indicates that clarifying municipal and district-level competent authorities for UUS utilization is key to addressing comprehensive UUS development issues. Flexibly adjusting competent authorities in response to urban development demands can effectively improve governance efficiency of public sectors. However, the current planning department-led management system is insufficient to meet UUS utilization demands under the context of urban renewal. The government function adjustment in 2014 also led to the disappearance of the interdepartmental coordination platform for the entire process of UUS utilization. Additionally, the current system still lacks mature management mechanisms for UUS land use rights grant, reuse of idle UUS and three-dimensional cadastral management systems during urban renewal.

(3) Shanghai has established a two-level UUS planning system integrated with the territorial space planning system. By legislation and establishing RAPs, statutory planning effectiveness has been granted to UUS plans at all levels. A government-dominated and market-driven UUS development mode has been constructed to achieve a win-win situation among the government, the public and private sectors in land development. However, the current system lacks unit level plans of UUS, making it difficult to implement the planning requirements of master level plans. Simultaneously, the compilation of UUS detailed plans also lacks a basis of upper level planning.

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