

Article

Identification and Analysis of Potential Open-Sharing Subjects of Unit-Affiliated Green Spaces in Shanghai Based on POI Data

Bo Liu, Sijun Zheng *, Lang Zhang *, Jialin Liu, Tingting Fu, Ruijun Hao and Ming Yin

Shanghai Engineering Research Center of Landscaping on Challenging Urban Sites, National Innovation Alliance of National Forestry and Grassland Administration on Afforestation and Landscaping of Challenging Urban Sites, Key Laboratory of National Forestry and Grassland Administration on Ecological Landscaping of Challenging Urban Sites, Shanghai Academy of Landscape Architecture Science and Planning, Shanghai 200232, China; liub68@mail2.sysu.edu.cn (B.L.); jialinliu@seas.harvard.edu (J.L.); ftt@shsyky.com (T.F.); hrj@shsyky.com (R.H.); ym@shsyky.com (M.Y.)

* Correspondence: zsj@shsyky.com (S.Z.); zl@shsyky.com (L.Z.)

Abstract: In the post-pandemic era, the need for accessible urban green open spaces has increased. There is an urgent need to accurately identify large-scale unit-affiliated green spaces and focus on the potential for open sharing. Therefore, using POI data from the Gaode map of Shanghai obtained via web crawler, combined with remote sensing image data and the current green space data, the subjects of unit-affiliated green spaces in the main urban area and five new towns of Shanghai were identified in 2021. On this basis, in-depth explorations were carried out in terms of the type and number of subjects, the overall layout, and the grading of potential open sharing. A new application path for identifying subjects of unit-affiliated green spaces based on the POI data was established. The analysis of the potential openness of the subjects strongly supports the open sharing of unit-affiliated green spaces; the open sharing of unit-affiliated green spaces can compensate for the deficiencies in the fairness and efficiency of urban green spaces.

Keywords: POI data; unit-affiliated green spaces; identification of ownership; potential open-sharing subjects; Shanghai



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1. Introduction

In the post-pandemic era, the growing demand for accessible green open spaces has made the intensive, efficient, and integrated use of green public spaces a top priority. In recent years, scholars have begun to shift their research focus towards smaller but more numerous green spaces, such as pocket parks and neighborhood gardens with service radii of 200–350 m [1–3], and affiliated green spaces [4,5] that are closer to people's work and life scales. In China's urban areas, a large proportion of the green spaces are affiliated with green spaces in the central urban area (accounting for 25–40%). However, they are mainly located within certain state-owned enterprises, universities, and government institutions, where public attributes are insufficient and low comprehensive utilization benefits [6]. The supply of public open spaces in urban green spaces can be tapped from affiliated green spaces belonging to various types of land uses, whose complex property rights and subject affiliation become the main obstacles to joint construction and sharing [7,8]. Existing studies have analyzed the significant contribution of ancillary green space to urban green public open space, mainly based on the data of green attributes in traditional urban land use. Nevertheless, previous studies and urban planning practice have not further explored how to realize the sharing of affiliated green spaces by urban residents due to the long-standing complex property rights and subject affiliation of affiliated green spaces [9,10]. The February 2023 publication, "Excerpts on Urban Work by Xi Jinping", discusses the practical needs of urban construction and development in the new era, highlighting people-centric, harmonious, livable, vibrant, and characteristic modern urban construction. Hence, in the

new development period, it is important to notice the opening and sharing of affiliated green spaces to residents. This increases the vitality of urban green spaces, optimizes the urban greening layout, and deeply explores the potential comprehensive benefits and planning practice paths that can be brought about through the open sharing of affiliated green space [11].

The concept of Private Owned Public Space (POPS) has been proposed, and related urban management policies have been formulated for over sixty years worldwide. Compared to traditional government-provided public open spaces, such as parks and squares, it refers to outdoor or semi outdoor spaces constructed and managed by private investors on private land or property rights, and exchanged for public use through government incentive mechanisms [12]. In 1961, the New York City District Regulations officially proposed the concept of private public space, which was made public through incentives such as plot ratio [13]. Several cities, including Los Angeles, Chicago, Toronto, Osaka, Singapore, and Hong Kong in China, have also introduced similar policies since then. The relevant theoretical research and policy practice provide a theoretical basis and demonstration experience for the open sharing and efficient composite utilization of affiliated green spaces [14–18]. In 2020, the Shanghai Landscaping and City Appearance Administrative Bureau established a working group to initiate the opening and sharing of affiliated green spaces (Open sharing of unit-affiliated green spaces: Refer to “Technical Guidelines for the Construction of Open Sharing of Unit Affiliated Green Spaces in Shanghai (Trial)”. <https://y.d4t.cn/iq44Nw>) (originally “tear down walls penetrate into green”); namely, opening affiliated green spaces to the public for sharing on the basis of unchanged land rights and usage attributes. They carried out a series of policy-making, technical research and development, and pilot projects for the opening and sharing of unit-affiliated green spaces. In 2020, five representative unit-affiliated green spaces were opened for sharing, including district governments and public institutions. Between 2021 and 2022, eight ministries jointly issued the “Guidelines on Promoting the Development of the Sharing Economy”, comprehensively advancing the opening and sharing of affiliated spaces and forming a project library of affiliated green spaces open for sharing during the 14th Five-Year Plan (105 places) and completing an additional 28 open-sharing upgrade projects. The opening and sharing of unit-affiliated green spaces in Shanghai has achieved excellent social effects and effectively increased the public activity space for residents in the central city. Therefore, it is imperative to promote the opening and sharing of unit-affiliated green spaces on a large scale. However, previous pilot projects for the opening and sharing of unit-affiliated green spaces also reflected many problems and technical bottlenecks that need to be urgently solved. The ownership of unit-affiliated green spaces is complex, and different types of ownership subjects have varying degrees of willingness to open and share unit-affiliated green spaces, as well as varying difficulty levels in the technical enhancement of greenery, funding demands, and subsequent management requirements. Therefore, identifying the ownership subjects is the foundation for the next step in implementing the open sharing of unit-affiliated green spaces. On this basis, how to efficiently and accurately identify the ownership subjects of a large number of unit-affiliated green spaces in Shanghai and analyze the potential for these subjects to open and share unit-affiliated green spaces has become a technical bottleneck that urgently needs to be broken.

Point of interest (POI) data sets, combining geographic location information and attribute classification information, have many advantages, including high openness, a large sample size, and detailed information coverage. To date, scholars have conducted a lot of applied research in the area of precise urban element extraction and functional area identification [19–23]. In addition, a series of steps in progress have been made in the identification, evaluation, and optimization of urban green space ecological spaces based on POI data [24–28]. Jiang Jiayi et al. [24] identified different functional areas in Shanghai, as well as the degree and scope of radiation of their urban functions, and evaluated the green space structure of Shanghai from different dimensions. Qi Ronghao et al. [25] created a new evaluation index—service pressure—based on POI data, quantifying the population

distribution and activity intensity, and evaluated the service capacity of parks and the degree of demand for park green spaces in different urban spaces. Wu Jing et al. [26] measured the spatial fitness between Weibo user check-in points and facility interest points in the blue space of Wuhan city based on Weibo data and POI data and evaluating the spatial value potential of blue spaces in Wuhan. Li Fangzheng et al. [27] evaluated the necessity of greenway connecting social infrastructure distribution areas through the kernel density calculation of POI and measured the degree of community infrastructure agglomeration. Zhan Mingsong et al. [28] used POI data to identify ecological (mixed) spaces and identified ecological space corridors using the minimum cumulative model and gravity model, based on comparing the resistance to bio-information flow caused by different types of POI elements. There are relatively few studies and practices that use POI data to identify and analyze the ecological space of urban green spaces and apply these techniques to the identification and analysis of the main body of ownership of urban affiliated green spaces. At present, urban green space planning and management departments classify urban-affiliated green spaces roughly into types (e.g., residential affiliated green spaces, road affiliated green spaces, and unit-affiliated green spaces) [29], but they do not further precisely identify the ownership subjects of the unit-affiliated green spaces. Therefore, it is of great significance to focus on the techniques for refined extraction and identification of urban elements based on POI data, further identify the ownership subjects of unit-affiliated green spaces, analyze the potential openness of affiliated green space subjects, and support the planning practice of opening and sharing unit-affiliated green spaces.

2. Subject and Data

2.1. Research Scope and Objects

As of 2023, Shanghai has a population of 24.9 million, making it the most populous urban area in China. As shown in Figure 1, Shanghai is located in the east of China and the scope of the study covers the main urban area of Shanghai and the five new major towns, and the total area of the research scope is approximately 1976 km².

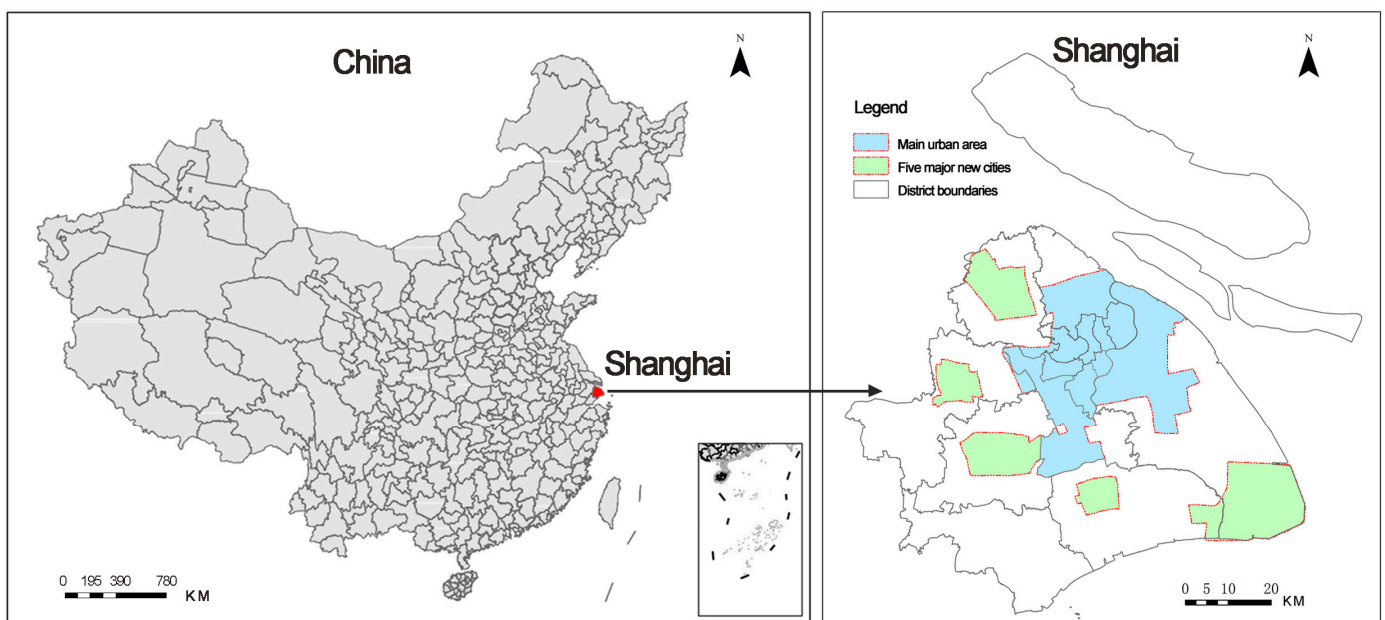


Figure 1. Location and Research Scope.

The objects of this study are unit-affiliated green spaces and their affiliation subjects. Affiliated green spaces refer to green spaces attached to all types of urban and rural construction land (excluding “green spaces”). Green spaces within public facilities, industry, warehousing and logistics, external transportation, municipal facilities, urban development reserve land, and other uses are referred to as unit-affiliated green spaces. The green

spaces within public facilities, industry, warehousing and logistics, external transportation, municipal facilities, urban development reserve land, and other uses are referred to as unit-affiliated green spaces. Please see the “Technical Guidelines for the Construction of Open Sharing of Unit-Affiliated Green Spaces in Shanghai (Trial)” <https://y.d4t.cn/iq44Nw>.

2.2. Data Source and Preprocessing

2.2.1. Data Source

(1) Source of POI data

POI data are a type of point-like spatial data that abstract the physical entities in the real world. Any geographical entity, including schools, hospitals, squares, shopping malls, etc., can be represented by POI. It represents the spatial location of geographical entities and contains rich attribute information. General POI data include coordinates, names, categories, etc. In this study, the Gaode Map POI data were crawled using Mars coordinates, the encrypted coordinates commonly used in domestic electronic maps, released by the National Surveying and Mapping Bureau in 2002. The original POI data also contain information such as telephone numbers and evaluations. In 2021, a total of 1,217,301 Gaode POI data for Shanghai were crawled.

(2) Image data

Google Satellite Maps Downloader was used to obtain high-resolution Remote sensing images. High-resolution remote sensing image data of Shanghai in 2021, Shanghai Urban Construction Coordinate System, with a resolution of about 1 m/pixel.

(3) Green space data

Vector data interpretation of green forest land in Shanghai in 2019, including vector data of four types of green spaces in Shanghai: public green spaces, protective green spaces, affiliated green spaces, and other green spaces. Attribute information for each green space patch included green space area, type of green space (major category and sub-category), and district name, etc. In addition, we corrected the 2019 green space vector data using the 2021 remote sensing imagery to filter out a small amount of error data in the green space vector data.

2.2.2. Data Preprocessing

(1) POI data preprocessing

POI data were divided into 23 primary categories and 265 secondary categories using Gaode Map. The primary categories of POI included: catering services, road ancillary facilities, place name address information, scenic spots, public facilities, companies, shopping services, transportation facilities services, financial insurance services, scientific education and culture services, motorcycle services, car services, car repair, car sales, business residences, life services, indoor facilities, sports and leisure services, access facilities, medical health services, government organizations and social groups, residential services, and events. Categories of POI data unrelated to this study were excluded, such as indoor facilities, place name address information (door numbers, building numbers), and events, etc.

(2) Green space data classification

The data were classified into primary categories such as urban park green space, affiliated green space, protective green space, etc., through the vector data interpretation of green forest land in Shanghai. Affiliated green space vector data were extracted. The secondary categories of affiliated green space vector data included residential-affiliated green space, road-affiliated green space, unit-affiliated green space, etc., from which unit-affiliated green space vector data were further extracted. Delete vector patch blocks of unit-affiliated green space that were smaller than 1000 square meters (According to the “Technical Guidelines for the Construction of Open Sharing of Unit Affiliated Green Spaces in Shanghai (Trial)”, affiliated green spaces of units with a concentration of green spaces of

more than 1000 square meters are encouraged to carry out open and shared construction in accordance with the standard of pocket parks).

(3) Remote sensing image data preprocessing

Using the remote sensing image processing software ENVI 5.6, the following preprocessing procedures were performed on the 2021 Shanghai remote sensing image data: cloud removal, ortho-rectification, precise rectification through administrative boundaries, etc.

3. Identification of Affiliation and Grading of Open Sharing Potential

3.1. Multi-Data Fusion and Correction

After data preprocessing, the reclassified overall POI data, remote sensing image data, unit-affiliated green space data, and administrative boundary data were integrated into a unified coordinate system. The remote sensing image data and administrative data serve as the base data, and corrections were made to the other data types, respectively, with errors controlled within half a pixel.

3.2. Identification of Affiliated Entities

Based on the target-oriented approach, the POI data beneficial to the identification of the affiliating entities of unit-affiliated green spaces were manually reclassified into 13 categories of affiliated entities: government organizations and social groups, scientific education and culture services, financial insurance services, catering services, companies, shopping services, car services, car repair, car sales, business residences, life services, sports and leisure services, residential services, medical health services, transportation facilities services. The corresponding sub-categories for each type are shown in Table 1.

Table 1. Types of Affiliating Entities of Unit-Affiliated Green Spaces.

SN	Major Categories	Sub-Category
1	Government Institutions and Social Organizations	Government and Social Organization-related, Government Offices, Foreign Institutions, Democratic Parties, Social Organizations, Judicial Institutions, Transportation Vehicle Management, Taxation Institutions
2	Scientific, Educational, and Cultural Services	Science, Education, and Cultural Sites, Museums, Exhibition Halls, Art Galleries, Libraries, Science and Technology Centers, Planetariums, Cultural Palaces, Archives, Media Institutions, Schools, Research Institutions
3	Financial and Insurance Services	Financial and Insurance Institutions, Banks, Bank-related, Insurance Companies, Securities Companies
4	Food Services	Food and Beverage Related Places, Leisure Food and Beverage Places, Coffee Shops, Tea Art Galleries, Cold Drink Shops, Pastry Shops, Malls
5	Companies and Enterprises	Companies and Enterprises, Renowned Companies, Companies, Factories
6	Shopping Services	Supermarkets, Flower, Bird, Fish, and Insect Markets, Home and Building Material Markets, Comprehensive Markets
7	Car Sales and Services	Automobile Sales, Car Rental, Automobile Service Related, Gas Stations, Other Energy Stations, Car Wash, Automobile Clubs, Car Repair
8	Commercial and Residential Properties	Commercial Residential-related, Residential Areas
9	Living Services	Life Service Places, Travel Agencies, Job Markets, Water Supply Service Offices, Electricity Supply Service Offices
10	Sports and Leisure Services	Sports and Leisure Service Places, Sports Stadiums, Golf Related, Entertainment Places, Holiday Places, Leisure Places
11	Residential Services	Residential-related Services, Hotels, Guest Houses
12	Medical and Health Services	Health and Medical Service Places, General Hospitals, Specialty Hospitals, Clinics, Emergency Centers, Disease Prevention Institutions, Health and Medicine Retail Stores, Animal Medical Places
13	Transportation Facility Services	Airports, Train Stations, Ports, Long-distance Bus Stations, Subway Stations, Light Rail Stations, Bus Stations, Parking Lots, Transit Ports, Taxis, Ferry Stations

3.3. Grading of Open Sharing Potential

In accordance with the preliminary research results of the open sharing of affiliated green space research group and the initial effects of the open sharing improvement project, the following insights were drawn. First, based on policy advocacy, there is great potential for open sharing in government, science, education, culture, finance, and other businesses and public sectors. Second, shopping markets, business centers, sports and leisure services, and other organizations are well placed to access open green environments and attract more people, with a high potential for open sharing. Finally, commercial residences, health and medical institutions that need to reduce people flow and maintain a quiet environment, and transportation service institutions that can cause certain disturbances and safety hazards to residents' lives and public environments have a low possibility of open sharing [6,30]. In addition to these, the potential for the open sharing of unit-affiliated green spaces belonging to other types of entities is at a medium level, which requires the exploration of effective property rights transfer incentive mechanisms and sharing strategies to publicize affiliated green spaces [11]. The research group also consulted some industry professors to participate in the discussion and made appropriate optimizations and adjustments based on the above insights.

Therefore, the potential for the open sharing of the 13 types of entities of unit-affiliated green spaces could be divided into three levels: high, medium, and low. The major and sub-categories of the POI data corresponding to entities of each level are listed in Table 2.

Table 2. Grading of Open Sharing Potential for Entities of Unit-Affiliated Green Spaces and their Corresponding Types.

Level	Major Category	Sub-Category
High	Government Institutions and Social Organizations	Government and Social Organization-related, Government Offices, Foreign Institutions, Democratic Parties, Social Organizations, Judicial Institutions, Transportation Vehicle Management, Taxation Institutions
	Scientific, Educational, and Cultural Services	Science, Education, and Cultural Sites, Museums, Exhibition Halls, Art Galleries, Libraries, Science and Technology Centers, Planetariums, Cultural Palaces, Archives, Media Institutions, Schools, Research Institutions
	Financial and Insurance Services	Financial and Insurance Institutions, Banks, Bank-related, Insurance Companies, Securities Companies
	Food Services	Food and Beverage Related Places, Leisure Food and Beverage Places, Coffee Shops, Tea Art Galleries, Cold Drink Shops, Pastry Shops, Malls
	Shopping Services	Supermarkets, Pet Markets, Home and Construction Material Markets, General Markets
	Sports and Leisure Services	Sports and Leisure Service Places, Sports Stadiums, Golf Related, Entertainment Places, Holiday Places, Leisure Places
Minor	Companies and Enterprises	Companies and Enterprises, Renowned Companies, Companies, Factories
	Car Sales and Services	Automobile Sales, Car Rental, Automobile Service Related, Gas Stations, Other Energy Stations, Car Wash, Automobile Clubs, Car Repair
	Living Services	Life Service Places, Travel Agencies, Job Markets, Water Supply Service Offices, Electricity Supply Service Offices
	Residential Services	Residential-related Services, Hotels, Guest Houses
Low	Medical and Health Services	Health and Medical Service Places, General Hospitals, Specialty Hospitals, Clinics, Emergency Centers, Disease Prevention Institutions, Health and Medicine Retail Stores, Animal Medical Places
	Transportation Facility Services	Airports, Train Stations, Ports, Long-distance Bus Stations, Subway Stations, Light Rail Stations, Bus Stations, Parking Lots, Transit Ports, Taxis, Ferry Stations
	Commercial and Residential Properties	Commercial Residential-related, Residential Areas

3.4. Research Steps

The identification and analysis of potential opening and sharing subjects of unit-affiliated green spaces involved three steps (Figure 2). The first step involved merging and calibrating multiple types of data, based on Shanghai's POI data and vector data

of unit-affiliated green spaces, to manually discern information about the green spaces' owning bodies. In the second step, this information was corroborated with the texture and spatial characteristics of objects in the remote sensing images of Shanghai, resulting in a database of Shanghai's unit-affiliated green spaces. In the third step, the POI data were reclassified based on the potential for open sharing by the affiliated subject, creating a database for the potential sharing and opening of unit-affiliated green spaces.

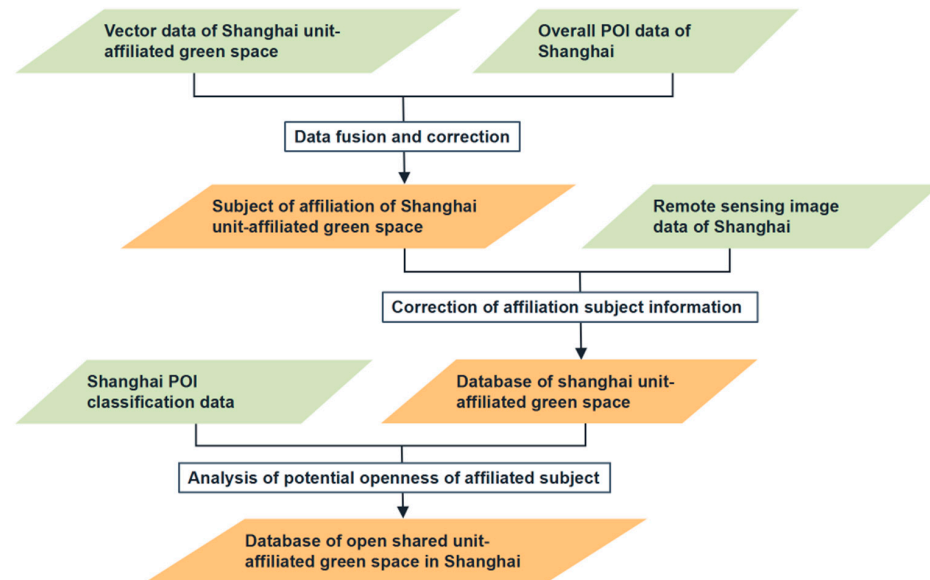


Figure 2. Technical Process Chart.

4. Results and Analysis

4.1. Overview of Subjects of Unit-Affiliated Green Spaces

The spatial distribution of unit-affiliated green spaces in the main urban area of Shanghai and five new cities are shown in Figure 3. The total area is 5156.08 hm², with 13,520 vector patches belonging to 5842 entities. Among them, Pudong New Area has the most entities at 1717, while Huangpu District has the fewest at 70.

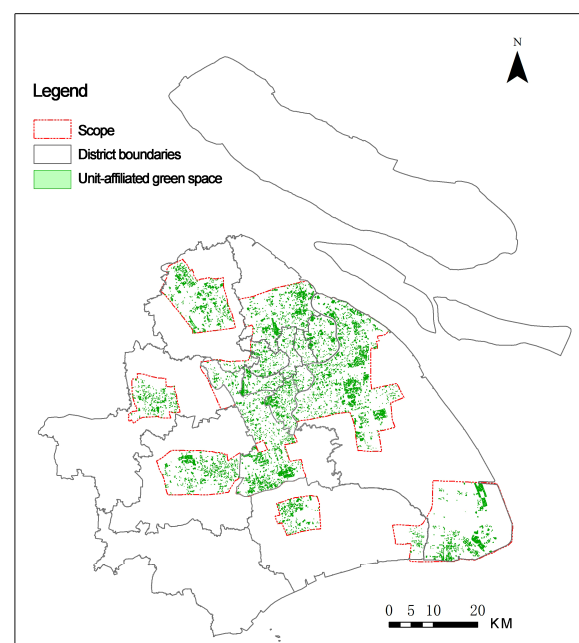


Figure 3. Spatial Distribution of Unit-Affiliated Green Spaces.

The addresses and names of the affiliating entities of the unit-affiliated green spaces were identified. The types of affiliating entities were categorized into major categories, sub-categories, and minor categories (Figure 4). There were a total of 13 major categories: catering services, companies and enterprises, shopping services, transportation facility services, financial and insurance services, scientific education and cultural services, car sales and services, commercial residences, living services, sports and leisure services, medical and healthcare services, government agencies and social organizations, and accommodation services.

#	A	B	C	D	E	F	G	H	I
1	FID	Area	Major categories in green space	middle categories in green space	Address	Name	major categories of belonging subjects	middle categories of belonging subjects	minor categories of belonging subjects
2	0	4969.19225	Affiliated green space	Unit-affiliated green space	180 Longcao Road	Shanghai Longhua Water Puri	Companies and Enterprises	factory	factory
3	1	1861.315663	Affiliated green space	Unit-affiliated green space	91 Xiqin Road	Qizhi Elementary School We	Scientific, Educational and Cultural Services	school	primary school
4	2	4529.737366	Affiliated green space	Unit-affiliated green space	8 Caobao Road	Shanghai Eighth People's Ho	Medical and Health Services	general hospital	general hospital
5	3	7903.751914	Affiliated green space	Unit-affiliated green space	180 Longcao Road	Shanghai Longhua Water Puri	Companies and Enterprises	factory	factory
6	4	4042.810889	Affiliated green space	Unit-affiliated green space	299 Longcao Road	Shanghai Longcao Middle Sch	Scientific, Educational and Cultural Services	school	middle school
7	5	1200.276461	Affiliated green space	Unit-affiliated green space	180 Longcao Road	Shanghai Longcao Middle Sch	Scientific, Educational and Cultural Services	school	middle school
8	6	2971.58571	Affiliated green space	Unit-affiliated green space	195 Longtian Road	Tianhua Software Park	Commercial and Residential Pr	industrial park	industrial park
9	7	3590.137198	Affiliated green space	Unit-affiliated green space	318 Shilong Road	Urban Management and Superv	Government Institutions and S	Government agency	District and county level governments
10	8	1184.867868	Affiliated green space	Unit-affiliated green space	999 Nanning Road	Shanghai Xuhui District Vet	Government Institutions and S	Government agency	District and county level governments
11	9	2038.882356	Affiliated green space	Unit-affiliated green space	66 Shilong Branch	Shanghai Shentong Subway E	Sports and Leisure Services	Leisure venues	Leisure venues
12	10	1865.886927	Affiliated green space	Unit-affiliated green space	588 Shilong Road	Shanghai Rail Transit Shilo	Companies and Enterprises	Company	Company
13	11	1790.246655	Affiliated green space	Unit-affiliated green space	588 Shilong Road	Shanghai Rail Transit Shilo	Companies and Enterprises	Company	Company
14	12	1158.870169	Affiliated green space	Unit-affiliated green space	9 Wuxuan Road	Xu Huirui Innovation Valley	Commercial and Residential Pr	Business and residential	Business and residential related

Figure 4. Examples of Types of the Subjects of Unit-Affiliated Green Space.

The area statistics of the major categories of unit-affiliated green spaces in the main urban area and five new cities are shown in Table 3. The largest areas belonged to the “Companies and Enterprises” and “Scientific Education and Cultural Services” categories.

Table 3. Area of Each Major Category of Unit-Affiliated Green Spaces/hm².

SN	Categories of Affiliated Entities	Main Urban Area	Five New Cities	Total
1	Government Institutions and Social Organizations	155.29	70.35	225.64
2	Scientific, Educational and Cultural Services	759.1	441.58	1238.56
3	Financial and Insurance Services	15.7	7.46	23.16
4	Food Services	10.65	2.23	12.88
5	Companies and Enterprises	1236.48	663.58	1900.06
6	Shopping Services	62.6	19.09	81.69
7	Car Sales and Services	18.91	9.47	28.38
8	Commercial and Residential Properties	380.15	198.72	578.87
9	Living Services	122.06	86.88	208.94
10	Sports and Leisure Services	230.31	321.11	551.42
11	Residential Services	42.79	16.85	59.64
12	Medical and Health Services	68.46	21.33	89.79
13	Transportation Facility Services	153.21	3.84	157.05

4.2. Analysis of Potential Open Sharing of Affiliated Subject

The total area of unit-affiliated green spaces in Shanghai is 5156.08 hm². The potential for open sharing by the affiliated subjects was divided into three levels: high, medium, and low. The area of unit-affiliated green spaces with high potential for open sharing is 2141.41 hm², with the spatial distribution shown in Figure 5 (left). The area of unit-affiliated green spaces with medium potential for open sharing is 2188.96 hm², with the spatial distribution shown in Figure 5 (middle). The area of unit-affiliated green spaces with no potential for sharing is 825.71 hm², with the spatial distribution shown in Figure 5 (right). Unit-affiliated green spaces with high potential for open sharing constitute 41.53% of the total unit-affiliated green spaces, indicating that the proportion of green spaces potentially open for sharing is relatively high.

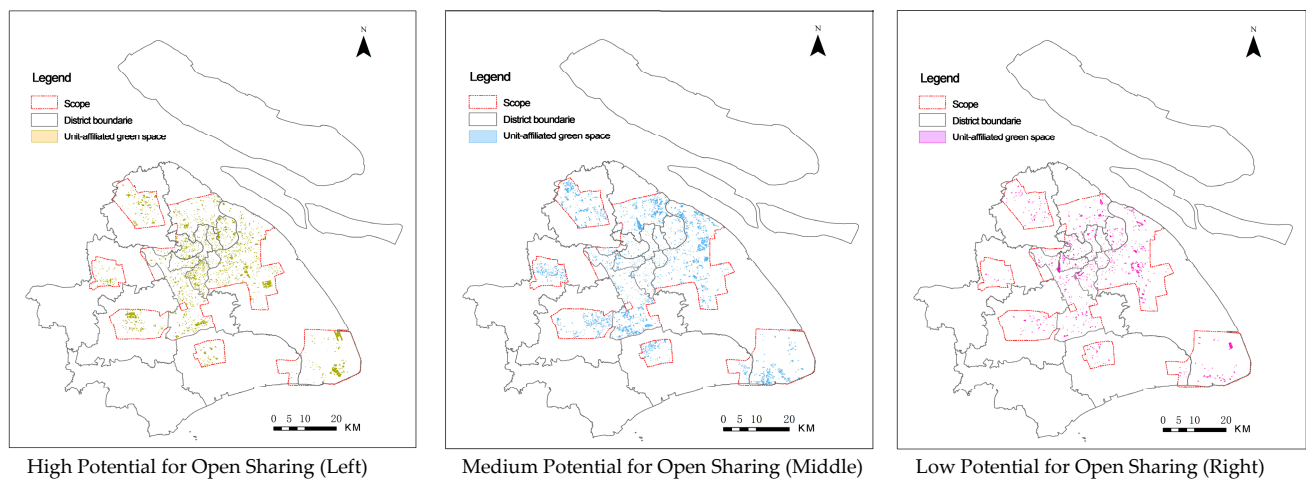


Figure 5. Distribution Map of Unit-Affiliated Green Spaces at Different Potential Open-Sharing Levels.

The affiliated entities with high potential for open sharing include: Government Agencies and Social Organizations, Scientific, Educational, and Cultural Services, Financial and Insurance Services, Catering Services, Shopping Services, Sports and Leisure Services, constituting six types (Table 2). As can be seen from Table 3, the Scientific, Educational, and Cultural Services category (i.e., scientific, educational and cultural venues, museums, exhibition halls, art galleries, libraries, science and technology museums, planetariums, cultural palaces, archives, media organizations, schools, research institutions) has the highest area among the 13 categories. As a result, the unit-affiliated green spaces owned by the Scientific, Educational, and Cultural Services category have the greatest potential for open sharing.

4.3. Unit-Affiliated Green Spaces with High Potential for Open Sharing

4.3.1. Spatial Distribution Characteristics in the Five Circles

The study area of the main urban area and the five new cities in Shanghai could be divided into five circles: within the inner ring, from the inner ring to the middle ring, from the middle ring to the outer ring, from the outer ring to within the main urban area, and the five new cities (Figure 6).

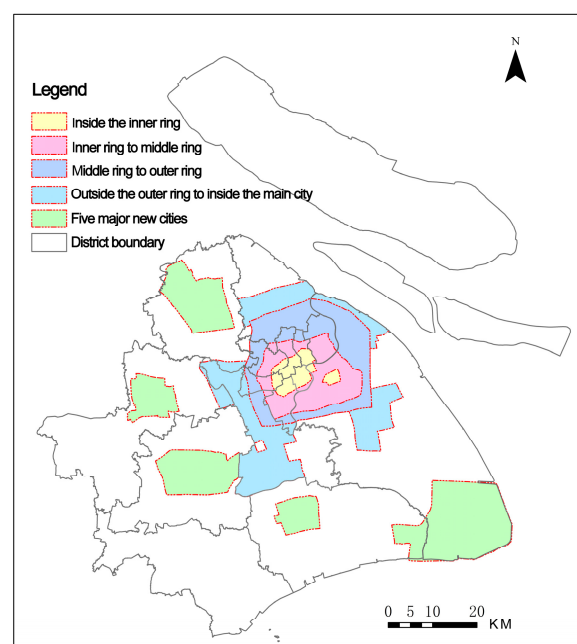


Figure 6. Spatial Scope of Each Circle.

The area and density of unit-affiliated green spaces with high potential for open sharing in the five circles are as follows (Table 4): within the inner ring of 97.48 hm², density of 1.22%; from the inner ring to the middle ring of 303.79 hm², density of 1.30%; from the middle ring to the outer ring of 345.31 hm², density of 0.99%; from the outer ring to within the main city of 533.01 hm², density of 1.10%; and the five new cities of 861.82 hm², density of 1.04%. From the inner ring to the five new cities, as the circle expands outward, the total area of unit-affiliated green spaces with high potential for open sharing tends to increase. Among these five circles, the density of unit-affiliated green spaces with high potential for open sharing is highest from the inner ring to the middle ring, while the density is lowest from the middle ring to the outer ring. Although the total area of unit-affiliated green spaces within the inner ring is small, the proportion of unit-affiliated green spaces with high potential for open sharing reaches the highest level of 64.93%. Thus, the inner ring has a larger potential space and urgency.

Table 4. Situation of Unit-Affiliated Green Spaces in Different Circles.

Circle	Within Inner Ring	From Inner Ring to Middle Ring	From Middle Ring to Outer Ring	From Outer Ring to within Main City	Five New Cities
Administrative Area Area/hm ²	8011.45	23,431.72	34,928.19	48,620.16	82,602.19
Area of Unit-Affiliated Green Spaces with High Potential for Open Sharing/hm ²	97.48	303.79	345.31	533.01	861.82
Density of Unit-Affiliated Green Spaces with High Potential for Open Sharing/%	1.22%	1.30%	0.99%	1.10%	1.04%
Unit-Affiliated Green Space Area/hm ²	150.13	1381.20	3269.17	1413.79	1861.73
Percentage of Unit-Affiliated Green Spaces with High Potential for Open Sharing within the Area's Unit-Affiliated Green Spaces/%	64.93%	21.99%	10.56%	37.70%	46.29%

According to the further analysis of the spatial agglomeration characteristics based on the size of the area of green space attached to the units with higher potential for open sharing, as shown in Figure 7, the three main agglomeration centers are: the western part of the new town of Chuansha in Pudong New Area (Number ① in the Figure 7); the northern part of the new town of Nanhui in Nanhui New City (Number ② in the Figure 7); the middle part of Guangfulin Street in Songjiang New City (Number ③ in the Figure 7); the three secondary clustering centers are: the central and western part of Wujing Town in Minhang District (Number ④ in the Figure 7); the northeastern part of Anting Town in Jiading New City (Number ⑤ in the Figure 7); the southern part of the new town of Nanhui in Nanhui New City (Number ⑥ in the Figure 7); the three general clustering centers are: the central part of Wujiaochang Street in Yangpu District (Number ⑦ in the Figure 7); the southern part of Zhangjiang Town in Pudong New Area (Number ⑧ in the Figure 7); the northwestern part of Xinjiangwan Street in Yangpu District (Number ⑨ in the Figure 7). The circles to which different levels of clustering centers belong are shown in Table 5, below, with the main and secondary clustering centers all located outside the outer ring, and the most main clustering centers are in the five new cities (especially Nanhui New City); the clustering centers in the areas within the outer ring are fewer, and within the middle ring, Yangpu District mainly has two general clustering centers.

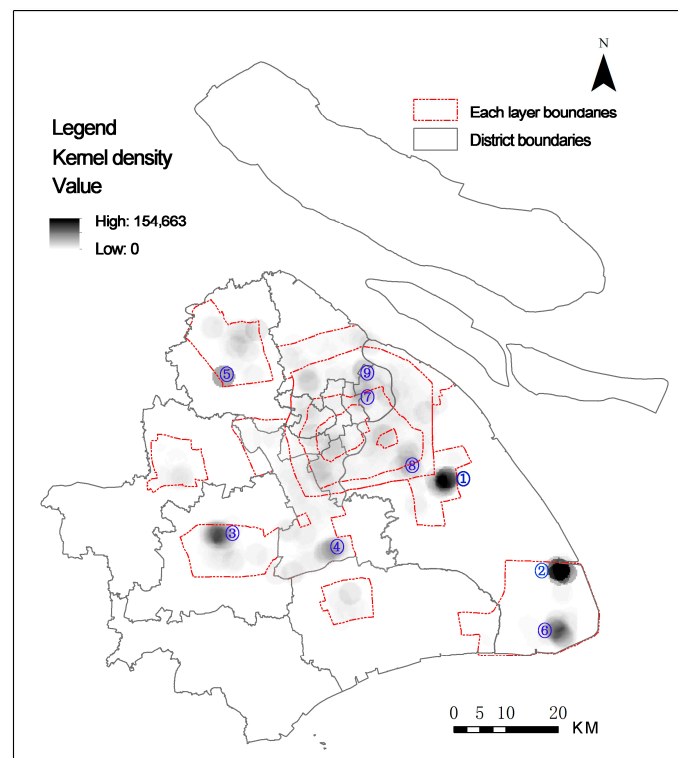


Figure 7. Kernel Density Analysis Map of Unit-Affiliated Green Spaces with High Potential for Open Sharing.

Table 5. Clustering Centers of Unit-Affiliated Green Spaces in Different Circles.

Circle	Within Inner Ring	From Inner Ring to Middle Ring	From Middle Ring to Outer Ring	From Outer Ring to Within Main City	Five New Cities
Main Clustering Centers				Western Part of Chuansha New Town, Pudong New Area ①	Northern Part of Nanhui New Town in Nanhui New City ②; Central Part of Guangfulin Street, Songjiang New City ③
Secondary Clustering Centers				Central and Western Part of Wujing Town, Minhang District ④	Northeastern Part of Anting Town, Jiading New City ⑤; Southern Part of Nanhui New Town, Nanhui New City ⑥
General Clustering Centers		Central Part of Wujiaochang Street, Yangpu District ⑦	Southern Part of Zhangjiang Town, Pudong New Area ⑧; Northwestern Part of Xinjiangwan Street, Yangpu District ⑨		

4.3.2. Distribution Characteristics of Each District in the Central City

As known from the above analysis results, the area of unit-affiliated green spaces in the central city area of Shanghai is relatively small and the level of clustering centers is lower, whereas the area of urban green spaces in the central city area of Shanghai is smaller, and the urgency of unit-affiliated open sharing is higher. Therefore, the unit-affiliated green spaces with high potential were further analyzed for open sharing in the seven districts of the central city of Shanghai. The spatial distribution of unit-affiliated green spaces with

high potential for open sharing in each administrative district of the central city of Shanghai is shown in Figure 8, and the area statistics are shown in Figure 9. Yangpu District has the most unit-affiliated green spaces with high potential for open sharing, reaching 133.01 hm^2 , while Huangpu District has the least, with 8.97 hm^2 .

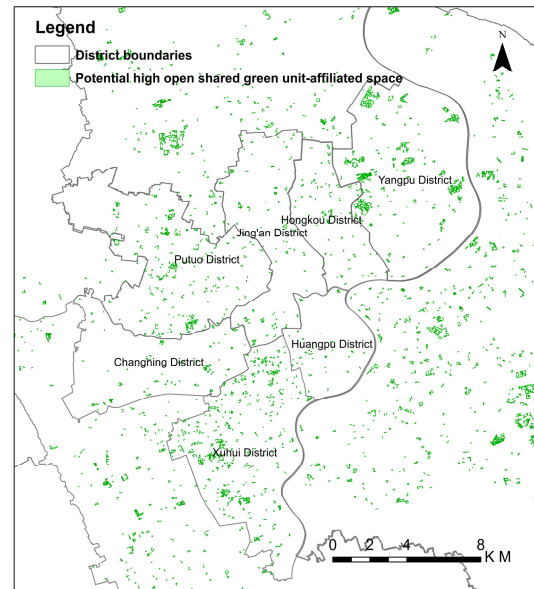


Figure 8. Distribution of Unit-Affiliated Green Spaces with High Potential for Open Sharing in Each District of Central City.

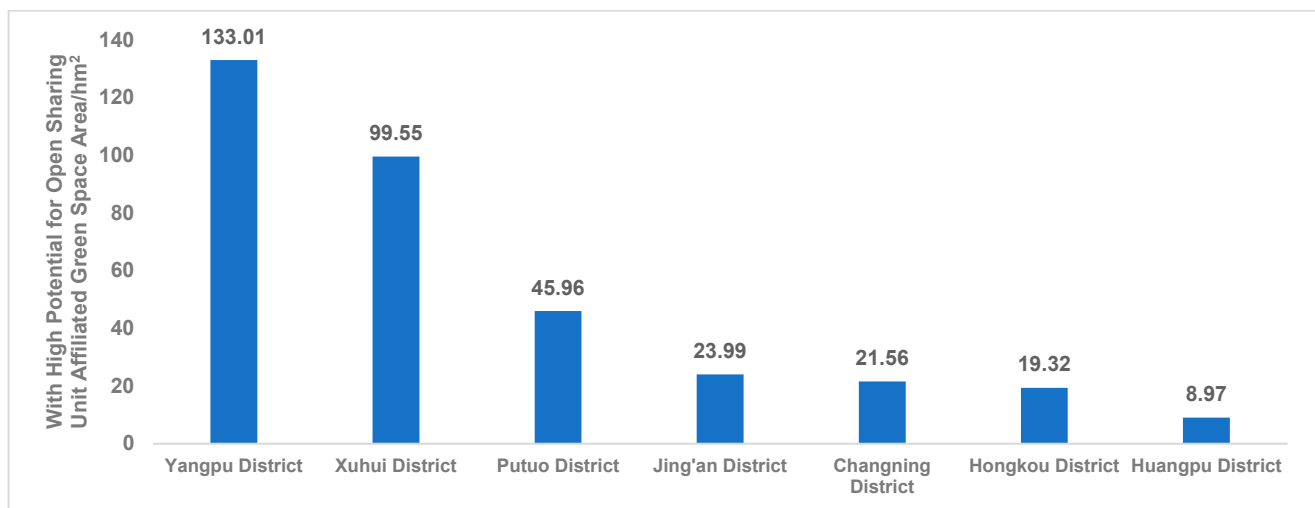


Figure 9. Area of Unit-Affiliated Green Spaces with High Potential for Open Sharing in Each District of the Central City.

5. Discussion

(1) Establishing a New Application Path to Identify the Affiliation of Unit-Affiliated Green Spaces using POI Data

In the current work, the identification of the subject of affiliated green spaces in the main city area and five new cities of Shanghai were achieved based on POI data. Moreover, in-depth analysis, in terms of the types and number of affiliated entities, overall layout, and potential for open sharing, were carried out. This method accurately constructed the database of affiliated green spaces the main city area and five new cities in Shanghai for the first time in China, which supports a series of practical work on the open sharing of

affiliated green spaces in Shanghai. The total area of unit-affiliated green spaces in the main city area and five new cities of Shanghai is 5156.08 hm², belonging to 5842 entities, which are classified into 13 major categories. Among them, the “companies and enterprises” and “scientific, educational, and cultural services” categories have the most affiliated entities. The “scientific, educational, and cultural services” category is likely to have a high potential for the open sharing of affiliated green spaces. Therefore, the category of “science, education and cultural services” (including science, education and cultural venues, museums, exhibition halls, art galleries, libraries, science and technology museums, planetariums, palaces of culture, archives, media organizations, schools and research institutes) has great potential in promoting the opening of affiliated green spaces. The spatial distribution of the unit-affiliated green spaces in the main city area and five new cities of Shanghai is relatively uneven, mainly concentrated in the five new cities (especially Nanhui New City). Additionally, the area of unit-affiliated green spaces within the middle ring is relatively small. The unit-affiliated green spaces within the inner ring with high potential for open sharing, have significant potential and urgency, especially in Jing’an District, Huangpu District, and Hongkou District, where the urgency for the open sharing of unit-affiliated green spaces is the highest.

(2) Analysis of the Affiliation’s Potential for Openness Strongly Supports the Open Sharing of Unit-Affiliated Green Spaces

Through statistical analysis of the potential for the open sharing of unit-affiliated green spaces belonging to government agencies and social groups, scientific, educational and cultural services, financial and insurance services, shopping markets, business centers, sports and leisure services, etc., it is known that the area of unit-affiliated green spaces with high potential for open sharing in the main city area and five new cities of Shanghai is 2141.41 hm², accounting for 41.53% of the total area of unit-affiliated green spaces, indicating a high proportion of space available for open sharing. The area of unit-affiliated green spaces within the middle ring is relatively small. Therefore, further statistics show that there is a potential for the high open sharing of 352.36 hm² of unit-affiliated green spaces in seven central urban districts of Shanghai (Yangpu, Xuhui, Putuo, Jing’an, Changning, Hongkou, Huangpu), among which Yangpu District has the most unit-affiliated green spaces with high potential for open sharing, reaching 133.01 hm², providing a great potential space and possible avenues for city residents to share green spaces. The open sharing of unit-affiliated green spaces can help tap into social resources, save the cost of relocation for new and renovated parks, bring the public closer to green ecological spaces, and meet the need for a high-quality life among the public.

(3) Open Sharing of Unit-Affiliated Green Spaces Compensates for Deficiencies in Urban Green Space Equity and Efficiency

A large number of studies have indicated that the per capita accessible park green space area in the central city area within the outer ring of Shanghai is insufficient [31], and the fairness and efficiency of the green space layout are unsatisfactory and not in line with the principle of resource scarcity in high-density areas [32–34]. Combined with the Shanghai Greening and City Appearance Bureau’s public green space 500-m coverage radius sweeping work, identifying the affiliated bodies of unit-affiliated green spaces and analyzing their potential for open sharing through POI data helps to sort out unit-affiliated green spaces within the coverage blind spots of public green spaces in the central city area of Shanghai. The relevant policies advocate that during the “Fourteenth Five-Year Plan” period, all unit-affiliated green spaces within the coverage blind spots of public green spaces should be opened to the maximum extent possible, and further clarify the staged implementation goals of unit-affiliated green spaces. The “Fourteenth Five-Year Plan for Ecological Space Construction and City Appearance Environment Optimization in Shanghai” points out that during the Fourteenth Five-Year period, Shanghai will implement the “Thousand Parks” construction project and build community parks and pocket parks in conjunction with unit green space open sharing. In the “Guidelines on Promoting the

Construction of Park City in Shanghai”, guiding unit green space open sharing is proposed as a major uplift measure. Via the planning and design of new unit green spaces and the open sharing of existing unit green spaces, the implementation of more than 200 sites will be promoted, with the construction of more than 20 demonstration sites for “special functions + parks”.

6. Conclusions

This study further broadens the scope of research on the privatization of private space. In the past, Privately Owned Public Open Space was mainly achieved by changing the ownership of land or changing the function of private space without changing the ownership of land. However, the open sharing of unit-affiliated green spaces is more inclined to achieve the urban living concept of sharing green ecology by removing and opening the boundaries of the space without changing the land ownership and spatial functions. In the post-pandemic era, the significance of unit-affiliated green spaces with high accessibility and openness to urban residents is substantial; hence, related policies and practical projects are highly implementable. In March 2022, the Shanghai Municipal Secretary and Mayor gave several instructions regarding the identification and potential open sharing research of unit-affiliated green spaces, stating that “this matter is very meaningful, it should be put on the agenda and efforts should be intensified,” with Mayor Peng Chenlei being instructed to take the lead in supervising, and the Shanghai Municipal Greening and City Appearance Bureau leading the opening of unit-affiliated green spaces. With the deepening of this research, the Shanghai unit-affiliated space opening pilot project, the three-year action plan project bank for affiliated space opening (2023–2025), in 2023, and the “Technical Guidelines for the Construction of Open Sharing of Unit Affiliated Green Spaces in Shanghai (Trial)” have been officially released. Based on the practical work of open sharing unit-affiliated green spaces, this research aims to promote the technical application of accurately identifying a wide range of unit-affiliated green space owners and analyzing the potential for open sharing to more cities based on POI data, helping more urban residents enjoy broader and more convenient green spaces. However, there is still substantial room for improvement in the intelligence and optimization of the technical path. Although the manual interpretation of POI data is precise and detailed, it is time-consuming and labor-intensive for large amounts of data. In the future, selecting the identification results from mature areas as training samples and combining them with manual visual interpretation technology will be taken into consideration to improve the efficiency of ownership identification.

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