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Walkability Measurement of 15-Minute Community Life Circle in Shanghai

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Abstract: Improvement of the walkability of the 15-min community life circle can enhance convenience for residents to obtain daily service facilities. In this paper, by obtaining the Point of Interest (POI) data of daily facilities used by Shanghai residents, we calculate the walk scores of community residents within 15-min walking distance using the walkability assessment tool and analyze the results with population density for spatial correlation. The results show that communities with high walk scores are concentrated in central areas, with low walk scores are scattered in the suburbs of the city. Walking scores are high for access from communities to bus stops and commercial services but low for access to parks and primary schools. The formation of a compact and accessible spatial layout can significantly improve the walkability of the community. Walkability is not only related to the construction of facilities in terms of quantity and space but is also influenced by the degree of spatial clustering in the community. It needs to be reasonably configured in conjunction with the spatial distribution of the community in order to effectively improve the utilization of facilities. Finally, community walkability is significantly and positively correlated with population density.

Keywords: walkability; walk score; 15-min walkable neighborhoods; public service facility; population density; China

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Citation: Yang, Y.; Qian, Y.; Zeng, J.; Wei, X.; Yang, M. Walkability Measurement of 15-Minute Community Life Circle in Shanghai. *Land* **2023**, *12*, 153. https://doi.org/10.3390/land12010153

Academic Editor: Fabrizio Battisti

Received: 27 November 2022
Revised: 21 December 2022
Accepted: 30 December 2022
Published: 2 January 2023

1. Introduction

First introduced in 2014, the "15-min community life circle" concept aims to create self-sufficient neighborhoods with essential functions of living, working, healthcare, commerce, education, and entertainment by decentralizing urban functions and services [1]. It follows a proximity-oriented strategy that focuses on the redistribution and placement of urban facilities and resources within the community [2]. Moreno envisioned dense and interconnected socially and functionally mixed communities based on human-scale design to encourage walking [3]. The Cities Climate Leadership Group (C40) recommended the 15-min city concept as a vital strategy for post-COVID recovery. In the wake of the new coronavirus (COVID-19) outbreak, the public wants future urban planning to focus on building adjacent facilities in a 15-min life circle rather than investing in large infrastructure projects to support the economy [4–6]. Fifteen-minute cities can lead to a higher quality of life in long-term planning, saving travel time by rethinking the transportation system to create more bicycles and sidewalks. It also promotes sustainable urban development by reducing environmental pollution caused by excessive car use, lowering per capita energy consumption and reducing pressure on public health systems [7–9]. At the same time, promoting walking in turn inspires the construction of parks, plazas, and public spaces in communities, better improving the physical activity and mental health of residents [10]. Walkability helps to reduce obesity rates among residents and promotes physical and mental health [11]. Fifteen-minute city strategies can provide advantages for public health and reduce crime rates by providing equal access to employment opportunities [12], services, and open spaces for everyone [13], as well as walkable environments in neighborhoods [14].

It also increases opportunities for socializing in public places, such as sidewalks, reduces transportation costs and enhances a sense of identity [15].

Scholars have focused on the equity [16], accessibility [17], and spatial distribution characteristics [18] of public service facilities in the life circle. Researchers have proposed various models and indicators to assess walkability in both subjective perception and objective dimensions [19]. Walkability is an appropriate term used to describe walking friendliness. The walkability approach has been validated and highly recommended for its effectiveness in measuring neighborhood walkability in different regions [20,21]. It avoids the shortcomings of time-consuming and laborious field observation and inaccurate subjective evaluation data [22]. European and American countries have developed evaluation methods and tools for walkability according to their own characteristics. Walk scores, as pointed out by American scholars in 2007, are now widely used for walking evaluation indexes. This method is used to measure walking around the world and has been widely used in many western countries. However, methods designed for land use planning in North America and Europe are not necessarily generalizable to developing countries, which have different built environments and cultural contexts than the West. Scholars such as Su developed a revised walk score tool to measure walkability in Chinese communities [23]. Weng demonstrated the link between walkability and health outcome indicators, and that walkable communities are not equally supplied or distributed [15], and it should have significant implications for health disparities and land use planning. Currently in developed cities in China, 15-min life circles are gradually becoming integrated into people's lives, yet few reports have been published on social inequalities in walkable communities in China [21]. It remains to be seen how community life circles will change in the future.

In this paper, we measure the walkability of the 15-min community life circle in Shanghai by collecting data, such as POI, geographic information road network, block length, and population density. The walkability of public facilities within the 15-min walking circle of the neighborhood are explored, such as schools, medical care, bus stops, parks, express delivery, restaurants, shopping and so on, and the spatial distribution characteristics are analyzed. Correlation analysis between the walkability and the population density is carried out to verify the experimental results, and the reasons are analyzed and suggestions for improvement are put forward based on the study.

2. Materials and Methods

2.1. Study Area and Data

Located in the Yangtze River Delta and adjacent to the East China Sea (Figure 1), Shanghai is the major industrial and commercial center, and the most rapidly urbanizing and developed metropolis in China. After undergoing significant socioeconomic transformations over the past forty years [24], Shanghai has experienced urban diseases, such as traffic congestion and increased morbidity [25]. In response, the local government has advocated "15-min walkable neighborhoods", aiming at providing basic public services, such as education, medical care, elderly care, and commercial services, within 15-min walking distance for each community. In this way, overall walking behavior will be promoted, resulting in equalization of public services, increased health motivation, and improved quality of urban life.

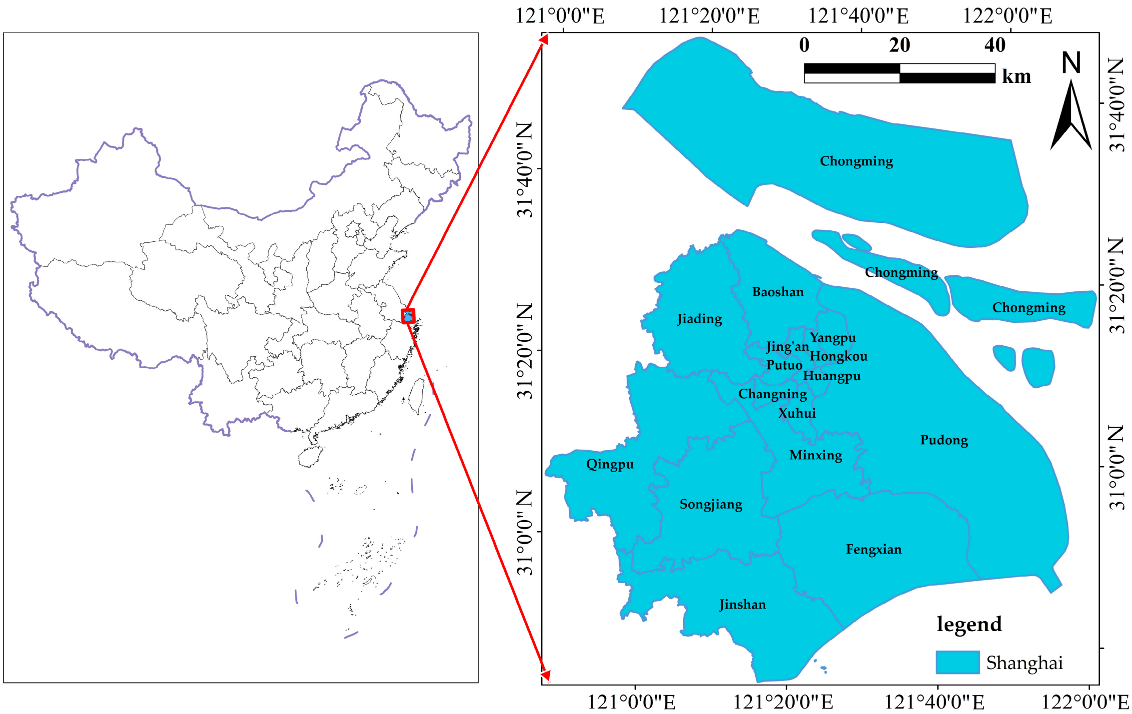


Figure 1. Study area.

The POI data of Shanghai communities and 14 types of public service facilities are obtained from AutoNavi Map (Table 1); the road network, block length and administrative district boundary data are obtained from the Shanghai land use map. The standard distance decay law was obtained, and the distance decay was divided into intersection decay and block length decay. According to the walking speed of 80/min; the range of 15-min life circle is calculated as 1200 m. The two-level walking system of 0–5 min (0–400 m), and 5–15 min (400–1200 m) were calculated separately to obtain the total walking score. Population density data were obtained from the Shanghai Statistical Yearbook 2021.

Table 1. Facility classification table for walkability calculation.

Principle Category	Sub-Category	Number of POI
Municipal utility	Park and square	4617
	Bus stop	17,951
Commercial service	Shopping malls (large supermarkets, vegetable markets)	13,439
	Convenience stores (grocery stores, fruit stores, hardware stores, department stores, small and medium-sized supermarkets, etc.)	8428
	Restaurant	80,024
Medical care	Clinic	26,624
	Pharmacy	28,566
Education	Kindergarten	2661
	Primary school	1063
	Middle school	1065
Living facility	Express delivery	2636
	Bank	14,572
	Barber Shop	11,206
	telecommunication hall	2711

2.2. *Research Methods*

2.2.1. Calculating Walkability: Walk Score

The walkability is calculated in ArcGIS by the following four steps.

(1) Network analysis based on ArcGIS. By obtaining the number of road intersections for spatial connection and network analysis, the road topology data is spatially connected to the road, and the spatial connection between the community points and the block length is established to establish a network data set;

(2) OD cost matrix analysis. The distance from each community location to the selected facility is calculated by creating a new OD cost matrix in the "Network Analyst" window of ArcGIS software. The starting points are then loaded as the communities and the destination points are loaded as the locations of the studied facility points, with the break value set to 1200 m. The final OD line will appear on the map by solving for it;

(3) Decay function. We adopt the tolerance time method [26,27], which represents the time threshold that a person can accept to arrive at facilities. The walking time is divided into two periods: 0-5 min, and 5-15 min. A Gaussian function was used to simulate the underlying decay function. The coefficient does not decrease during 5 min but continuously decreases to 0 at the end of 15 min. The decay rate R(t) is calculated by Equation (1).

$$R(t) = \begin{cases} 1, & if \quad t \leq 5\text{min} \\ y_0 + ae^{-\frac{(t-b)^2}{2c^2}}, & if \quad 5 < t \leq 15\text{min} \end{cases} \tag{1}$$

where y_0, a, b, and c are real constants, expected value $\mu = b$, b = 5, and variance $\sigma^2 = c^2$.

(4) Walk score correction and normalization of scores to 0–100. Once the original walk scores are calculated based on distance, the scores are modified by the decay factors for street intersections and block lengths. After obtaining the walk score for each community, the maximum walk score was selected in order of walk score. The walk score of each community was divided by the maximum value and then multiplied by 100 to normalize the walk score to 0–100. The walk score was corrected and the scores were normalized to 0–100.

2.2.2. Coverage Rate

The coverage rate of various public service facilities within the 15-min community life circle in Shanghai is calculated with the residential community as the center. If a community can reach a certain facility within 1200 m of the road length, it means that the residential community meets the standard coverage of this public service facility within 15 min walking distance.

$$C_{i,j,s} = \begin{cases} 1, \exists F_j \subset C_{i,s} \\ 0, others \end{cases} \tag{2}$$

$$CR_{i,j} = \frac{\sum_{s=1}^{m_i} C_{i,j,s}}{m_i} \tag{3}$$

$$TCR_j = \frac{\sum_{i=1}^{16} \sum_{s=1}^{m_i} C_{i,j,s}}{\sum_{i=1}^{16} m_i} \tag{4}$$

"i" represents one of the 16 administrative districts under the jurisdiction of Shanghai, "s" represents a community, "j" represents one of the 14 different types of facilities studied, and F_j represents one of the j-type facilities. $C_{i,s}$ is the community "s" in an administrative area "i"; $C_{i,j,s}$ represents whether there is a facility F_j within the walking circle of $C_{i,s}$ within 1200 m; $CR_{i,j}$ is the coverage rate of facility "j" in the administrative area "i". "m_i" represents the number of communities in an administrative district "i", and TCR_j represents the coverage rate of facility "j" in the whole Shanghai.

2.2.3. Spatial Analysis

The bivariate local Moran's I statistic [28] is performed to identify the spatial pattern of 15-min community life circles using a spatial weight matrix based on proximity distance.

In the study presented here, the statistic captures the correlation between the density of pedestrian groups in a certain administrative area and the average number of types of facilities that are accessible to the communities in the district. The number of types of facilities that are accessible on average within a 15-min walk for all communities in an administrative district can reflect the overall level of walkability of the communities in that district. More specifically, it can be used to detect spatial clusters and spatial outliers. "High-high" clusters (where the population density of a district and the community walkability of the surrounding places are both high) and "low-low" clusters (where the population density of a district and the community walkability of the surrounding places are both low) indicate a significant positive spatial correlation between population density and the accessibility of facilities in a 15-min community life circle. In addition, the spatial outliers include "high-low" outliers (high population density in a low walkability surroundings) and "low-high" outliers (low population density in areas with high walkability), indicating a mismatch in the facility configuration of 15-min community life circle.

3. Results

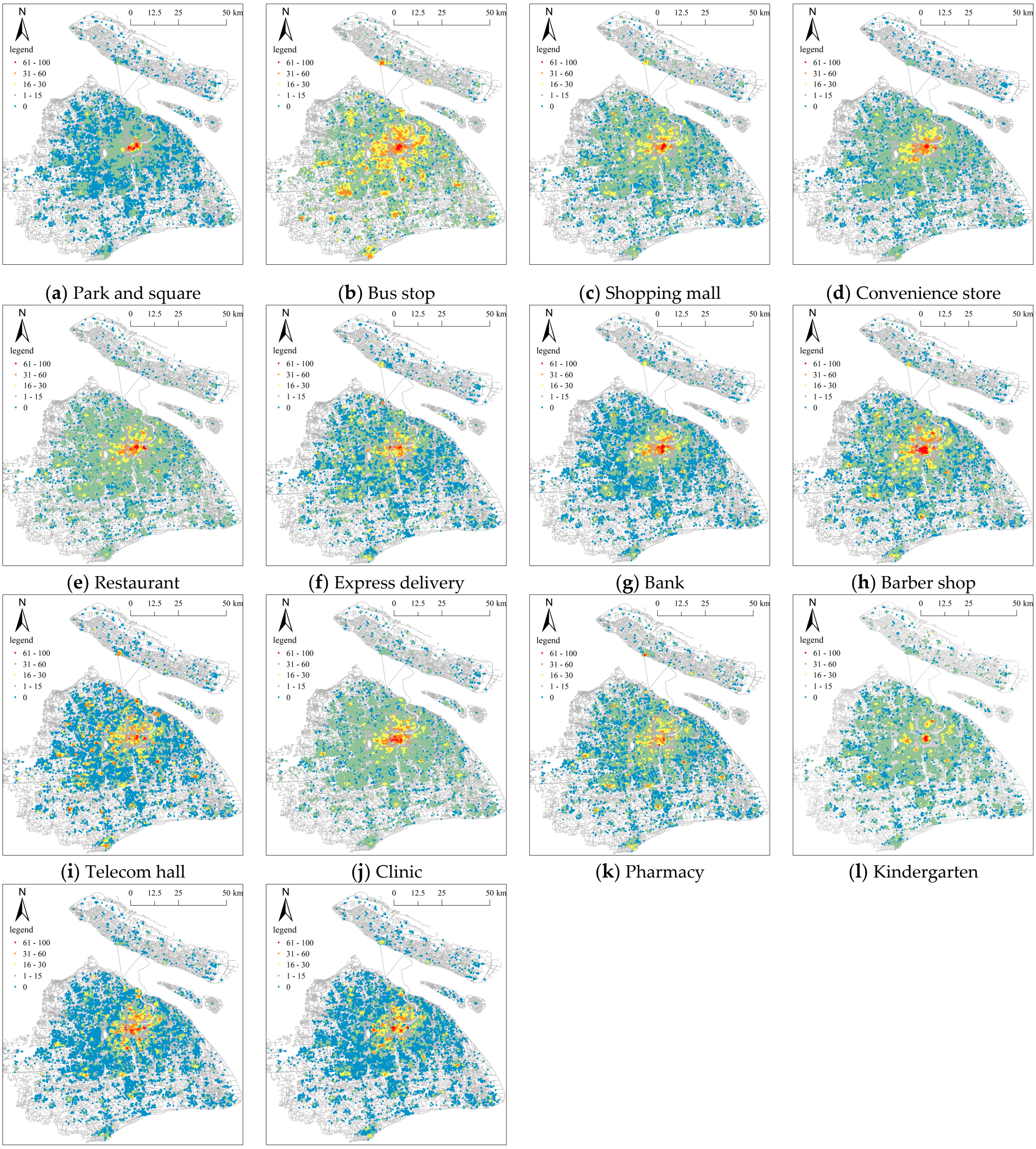
3.1. Calculation of the Walkability of Various Service Facilities in the Life Circle

After aggregating the initial scores, we group the scores into a 0–100 scale (Table 2). Specifically, communities with higher scores are more walkable. The higher the walkability, the more convenient it is to get to such facilities from the community within the range of 1200 m. That is, it is possible to walk to that type of facility in the shortest amount of time, and the facility can be better used by adjacent residents. A smaller walkability (greater than 0) indicates that the neighborhood residents can reach the facility within 1200 m, but the walking time is longer. A walkability of 0 indicates that there are no such facilities within 1200 m of the neighborhood.

Table 2. Grade of the 15-min walkable neighborhoods score.

Score	Description
61–100	Highly walkable. Daily trips do not rely on a vehicle.
31–60	Very walkable. The majority of daily trips rely on walking.
16–30	Moderately walkable. Part of daily trips rely on walking.
0–15	Somewhat walkable. The majority of daily trips rely on a vehicle.
0	Car-Dependent. Nearly all daily trips rely on a vehicle.

As shown in Figure 2, each colored point in the figure indicates a community. According to the graded walking score to different facilities, the blue community point with a walking score of zero indicates that the community cannot reach that type of facility within 1200 m. It can be visually seen that the overall walking score from communities to bus stops is higher and to parks and squares is lower among municipal utilities. This indicates that a mega-city such as Shanghai has very convenient transportation facilities, but lacks space for residents to relax on a daily basis. While recreation as one of the four functions of cities (Athens Charter proposes four functions of cities: living, working, recreation, and transportation), parks and green spaces are crucial for the physical and mental health of residents [29–31]. Among the commercial service facilities, the walking score from the community to shopping malls, convenience stores, and restaurants is high. Among the living facilities, the walking score of barber stores is relatively high, followed by express delivery and banks, and the walking score of telecommunication hall is low. Among medical and health facilities, clinics have a higher walking score than pharmacies. Among the educational facilities, kindergartens have the highest walking score, and middle schools have the worst walking score. As early as the neighborhood unit theory, it was proposed that the residential area should have an primary school as the central building, surrounded by other service facilities, and that children should not go to school more than half a mile. The Neighborhood Unit Theory was proposed by Clarence Perry in 1992 to respond to the problem of increasing motor vehicle traffic on urban roads, at the time threatening the elderly and children crossing the streets, by organizing residential areas with neighborhood units as cells [32,33]. The current substandard allocation of primary school space in Shanghai and the large role of primary school in the 15-min life circle should be taken into account and subsequent planning should improve the walkability from neighborhoods to primary school.



(**a**) Park and square (**b**) Bus stop (**c**) Shopping mall (**d**) Convenience store

(**e**) Restaurant (**f**) Express delivery (**g**) Bank (**h**) Barber shop

(**i**) Telecom hall (**j**) Clinic (**k**) Pharmacy (**l**) Kindergarten

(**m**) Primary school (**n**) Middle school

Figure 2. Walking score analysis charts of different facilities. (**a**) Park and square; (**b**) Bus stop; (**c**) Shopping mall; (**d**) Convenience store; (**e**) Restaurant; (**f**) Express delivery; (**g**) Bank; (**h**) Barber shop; (**i**) Telecom hall; (**j**) Clinic; (**k**) Pharmacy; (**l**) Kindergarten; (**m**) Primary school; (**n**) Middle school.

On the whole, the walkability of facilities of a commercial nature is high, but the walkability of facilities of a public welfare nature concerning education and recreation functions is generally low, reflecting that Shanghai still attaches importance to economic development and pays less attention to residents' well-being.

3.2. Evaluation of the Supply Level of Facilities in "15-Min Walking Circle"

Table 3 is derived from Equations (2) and (3). The coverage rates of various facilities in Huangpu, Yangpu, Hongkou, Xuhui, Jing'an, Putuo, and Changning districts in the central city are all high, while Chongming, Qingpu, and Fengxian districts, which are located on the periphery, have lower coverage rates. Figure 3 is derived from Equation (4) through which it can be seen that bus stations, restaurants, and clinics have the highest average coverage rates, all of which are above 0.9. However, the coverage rates of parks and squares, telecommunication halls, middle schools, and primary schools are lower.

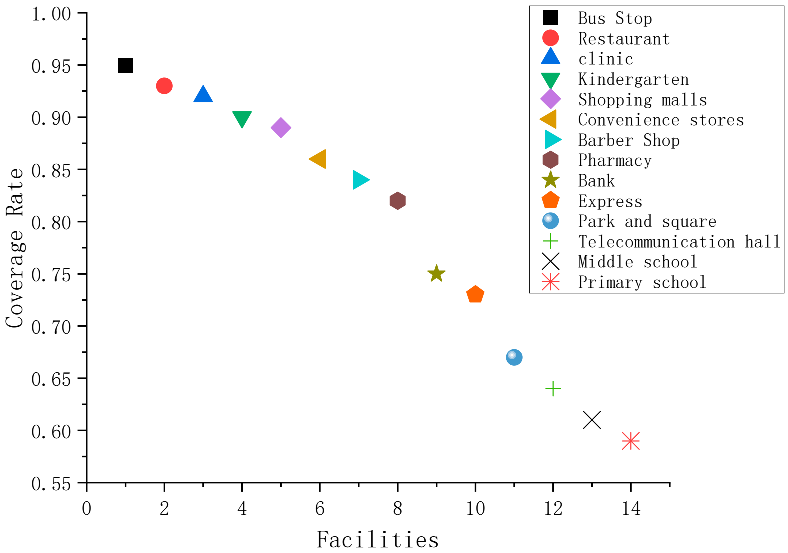
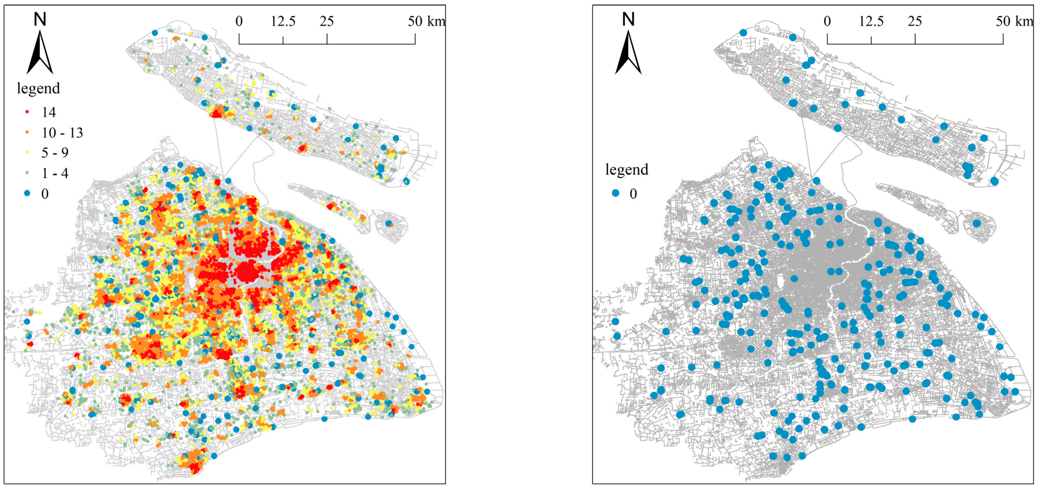


Figure 3. Facility average coverage.

The red dots represent communities with full coverage of 14 types of facilities within 1200 m (Figure 4a), and the blue dots represent communities that are not covered by even one type of facility (Figure 4b). It can be seen that the communities in the central area have the most types of facilities covered, and from the central area to the edge of the city, the types of facilities covered by the communities gradually become less. The layout of the communities with 0 types of facility coverage are very scattered. To meet the facility coverage standards of these scattered communities, it is inevitable to build a large number of facilities, which will cause unnecessary waste. It can be seen that the coverage rate of facilities has a strong relationship with whether the communities layout is concentrated or dispersed, not just the number of facilities.

Table 3. Facility coverage.

Coverage Rate in 16 Districts	Municipal Utility		Commercial Service			Living Facility				Medical Care		Education		
	Park and Square	Bus Stop	Shopping Mall	Convenience Store	Restaurant	Express Delivery	Bank	Barber Shop	Telecom Hall	Clinic	Pharmacy	Kindergarten	Primary School	Middle School
Huangpu	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Xuhui	0.85	1.00	0.99	1.00	1.00	0.86	1.00	1.00	0.75	1.00	0.96	0.99	0.85	0.84
Changning	0.97	0.99	0.99	0.99	0.99	0.96	0.97	0.99	0.93	1.00	0.95	0.99	0.78	0.87
Jing'an	0.87	0.97	0.99	1.00	1.00	0.95	0.97	1.00	0.94	1.00	0.99	0.97	0.95	0.88
Putuo	0.75	0.98	0.97	0.97	0.98	0.70	0.89	0.90	0.72	0.98	0.85	0.95	0.46	0.69
Hongkou	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.78	1.00	1.00	1.00	0.95	0.94
Yangpu	0.88	1.00	1.00	0.99	1.00	0.91	0.96	0.98	0.88	1.00	0.97	0.99	0.89	0.92
Minhang	0.53	0.93	0.83	0.88	0.92	0.63	0.68	0.79	0.46	0.92	0.76	0.91	0.47	0.45
Baoshan	0.55	0.90	0.89	0.88	0.92	0.70	0.68	0.83	0.58	0.91	0.79	0.87	0.50	0.44
Jiading	0.53	0.92	0.87	0.83	0.92	0.66	0.56	0.80	0.49	0.91	0.75	0.86	0.41	0.38
Pudong	0.53	0.93	0.81	0.84	0.90	0.56	0.68	0.76	0.55	0.92	0.74	0.87	0.49	0.45
Jinshan	0.62	0.93	0.78	0.72	0.88	0.64	0.64	0.73	0.61	0.90	0.76	0.82	0.51	0.50
Songjiang	0.43	0.97	0.85	0.85	0.93	0.69	0.50	0.76	0.48	0.93	0.71	0.82	0.26	0.33
Qingpu	0.49	0.95	0.81	0.78	0.89	0.52	0.54	0.73	0.41	0.89	0.65	0.84	0.33	0.34
Fengxian	0.43	0.91	0.73	0.67	0.82	0.49	0.51	0.64	0.39	0.81	0.58	0.74	0.27	0.37
Chongming	0.35	0.77	0.69	0.39	0.68	0.38	0.46	0.51	0.33	0.58	0.63	0.73	0.34	0.29

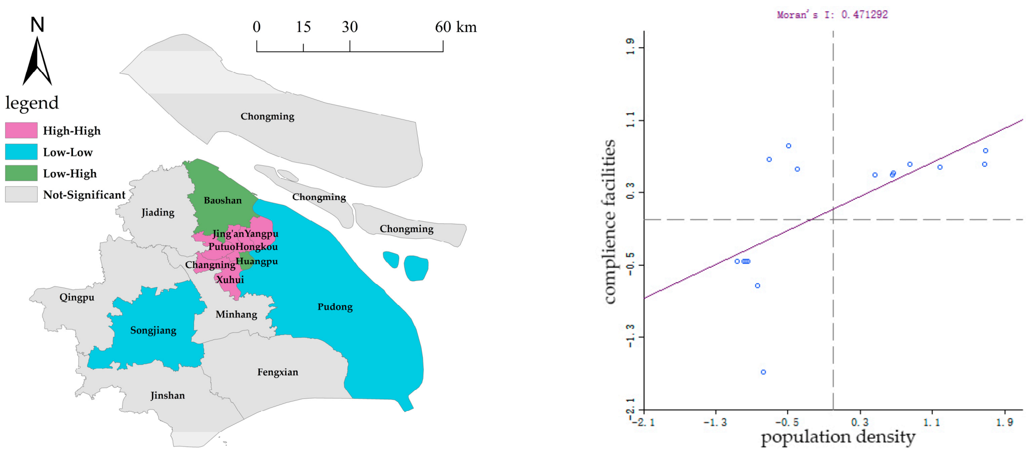


(**a**) (**b**)

Figure 4. The number of types of attainment facilities in each community within the 15-min life circle. (**a**) The number of types of attainment facilities in all communities; (**b**) The communities with 0 types of attainment facilities.

3.3. Spatial Analysis between Population Density and Overall Level of Walkability of the 15-Min Walkable Neighborhoods

The results of the bivariate cluster analysis are shown in Figure 5a. Eight administrative districts (50%) fall into the "high-high" (6, 37.5%) and "low-low" (2, 12.5%) clusters, which are located in close proximity to each other in the north-central area of the city. This indicates that the population density is high in the central part of the city and the facilities are largely accessible within a 15-min walkable neighborhoods. The two "low-high" outliers (12.5%) are scattered in the eastern Pudong New Area and the southwestern Songjiang Area, which are characterized by low population density but high walkability surroundings. These two areas may face a surplus of facilities, resulting in unnecessary waste. There are no "high-low" outliers, there are no areas with high population density but low walkability surroundings.



(**a**) (**b**)

Figure 5. Local spatial patterns (Bivariate local Moran's I) between population density and the overall level of walkability of the 15-min walkable neighborhoods in 16 districts. (**a**) LISA Cluster Map; (**b**) Moran Scatter Plot.

The results of the analysis of the bivariate clustering Moran index are shown in Figure 5b. The Moran index result of 0.47 illustrates that the overall level of walkability of the 15-min walkable neighborhoods and population density in the 16 administrative districts are positively correlated. There is a strong correlation between the construction of facilities in 15-min walkable neighborhoods and population distribution, and this result verifies the reasonableness of the walkability level of communities in Shanghai.

4. Discussion and Conclusions

The walking scores of communities to various facilities within a 1200-m range are calculated and corrected by establishing the street network topology and collecting POI of communities in Shanghai and 14 types of facilities related to daily lives of residents. Bivariate local Moran's I statistics of overall neighborhood walkability levels and population density for the 16 administrative districts under the jurisdiction of Shanghai were used to draw the following conclusions.

Within the 15-min life circle, the coverage rate of bus stops to communities is the highest, the coverage rates of commercial service facilities, such as restaurants, shopping malls and convenience stores are relatively high, and the coverage rates of medical and health facilities, such as clinics and pharmacies, are also high overall. However, the coverage rates of facilities, such as express delivery, parks, telecommunication halls, middle schools and primary schools are low. Ensuring the basic living needs of all community residents is conducive to a healthy living environment. The focus is on building basic facilities (e.g., parks and schools) for residents living in suburban communities. The facilities of parks and primary schools can have a significant impact on the daily lives of residents. Therefore, it is necessary to focus on improving the facilities of parks and primary schools to ensure a reasonable allocation of space.

The walkability is not only related to the number and spatial distribution of facilities but also to the degree of clustering and dispersion of the spatial distribution of communities. Communities with 0 facility coverage are extremely scattered in spatial distribution, indicating that a scattered layout of the communities is not conducive to the utilization of facilities, and this phenomenon can be improved by increasing the spatial clustering of communities. The construction of facilities is not better in terms of quantity, too many will cause unnecessary waste and should be closely linked to the location of community sites to achieve a reasonable distribution of spatial facilities.

Population density and the overall level of walkability of the 15-min walkable neighborhoods in the 16 administrative districts of Shanghai are positively correlated, and in general the higher the population density the more walkable the community. In addition to population density, walkability is also influenced by the age and economic level of the population, which is worthy of subsequent correlation studies. Areas with "high-high" outliers and communities with high walking score are concentrated in central areas, suggesting that older central areas in Shanghai have small neighborhoods and dense streets that are pedestrian-friendly [34]. The "low-low" outliers and less walkable communities are scattered in the urban fringe. This finding is consistent with previous studies of downtown neighborhoods in cities in Western countries [35–37].

In terms of facility type construction, the number of facilities in parks and squares, telecommunication halls and primary schools should be increased. Their spatial configuration should be reasonably optimized, and the neighborhood coverage of their facilities should be improved; especially the number of parks and squares should be increased. In Shanghai, where the economic level is growing rapidly, improving the walking score of parks and squares has a great effect on improving the happiness of residents. However, the optimal construction of facilities does not only increase the number of facilities to be built but also requires reasonable site selection in combination with population and other factors. For facilities with low utilization rate caused by unreasonable spatial distribution, the number of this facility should be appropriately reduced or several facilities should be combined into one facility to avoid unnecessary space waste. As for the optimization of the spatial layout of the community, the communities scattered in the suburbs of the city can be gathered together spatially to increase the density of the community, so as to facilitate the reasonable layout of facilities and services.

The formation of a compact and accessible layout is related to land use planning. A highly walkable community is closely connected to a rich and diverse functional area that can be easily reached on foot [38]. A compact layout is thought to enhance walkability by providing more direct and shorter destination paths [39,40]. In addition, walkability should be considered an important indicator for future community scale planning [41].

Author Contributions: Conceptualization, Y.Q. and Y.Y.; methodology, J.Z.; software, Y.Y.; validation, X.W., Y.Q. and Y.Y.; formal analysis, M.Y.; investigation, Y.Y.; resources, Y.Q.; data curation, X.W.; writing—original draft preparation, Y.Y.; writing—review and editing, X.W.; visualization, J.Z.; supervision, Y.Q.; funding acquisition, Y.Q. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China (Grant No. 71861024), the Major Research Plan of Gansu Province (Grant No. 21YF5GA052), the 2021 Gansu Higher Education Industry Support Plan (Grant No. 2021CYZC-60), the "Double-First Class" Major Research Programs, Educational Department of Gansu Province (Grant No. GSSYLXM-04), the United Fund of Lanzhou Jiaotong University and Tianjin University (Grant No. 2021057), the Philosophy and Social Science Planning Project of Gansu Province (Grant No. 2021YB058), the Higher Education Innovation Fund Project of Gansu Province (Grant No. 2020B—113), and the National Social Science Foundation of China (Grant No. 15BJY037).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: Thanks to all experts for their help in the building of the model in this study. All individuals included in this section have consented to the acknowledgment.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ferrer-Ortiz, C.; Marquet, O.; Mojica, L.; Vich, G. Barcelona under the 15-Minute City Lens: Mapping the Accessibility and Proximity Potential Based on Pedestrian Travel Times. *Smart Cities* **2022**, *5*, 146–161. [CrossRef]
2. Balletto, G.; Ladu, M.; Milesi, A.; Borruso, G. A Methodological Approach on Disused Public Properties in the 15-Minute City Perspective. *Sustainability* **2021**, *13*, 593. [CrossRef]
3. Noworól, A.; Kopyciński, P.; Hałat, P.; Salamon, J.; Hołuj, A. The 15-Minute City—The Geographical Proximity of Services in Krakow. *Sustainability* **2022**, *14*, 7103. [CrossRef]
4. Chen, L.; Liu, L.; Wu, H.; Peng, Z.; Sun, Z. Change of Residents' Attitudes and Behaviors toward Urban Green Space Pre- and Post- COVID-19 Pandemic. *Land* **2022**, *11*, 1051. [CrossRef]
5. Wang, S.; Li, A. Impacts of COVID-19 Lockdown on Use and Perception of Urban Green Spaces and Demographic Group Differences. *Land* **2022**, *11*, 2005. [CrossRef]
6. Yip, W.; Ge, L.; Ho, A.H.Y.; Heng, B.H.; Tan, W.S. Building community resilience beyond COVID-19: The Singapore way. *Lancet Reg. Health West Pac.* **2021**, *7*, 100091. [CrossRef] [PubMed]
7. Pérez, K.; Olabarria, M.; Rojas-Rueda, D.; Santamariña-Rubio, E.; Borrell, C.; Nieuwenhuijsen, M. The health and economic benefits of active transport policies in Barcelona. *J. Transp. Health* **2017**, *4*, 316–324. [CrossRef]
8. Liu, X.; Wang, M.; Qiang, W.; Wu, K.; Wang, X. Urban form, shrinking cities, and residential carbon emissions: Evidence from Chinese city-regions. *Appl. Energy* **2020**, *261*, 114409. [CrossRef]
9. Shaaban, K.; Abdur-Rouf, K. Assessing Walking and Cycling around Schools. *Sustainability* **2020**, *12*, 10607. [CrossRef]
10. Zuniga-Teran, A.A.; Orr, B.J.; Gimblett, R.H.; Chalfoun, N.V.; Going, S.B.; Guertin, D.P.; Marsh, S.E. Designing healthy communities: A walkability analysis of LEED-ND. *Front. Archit. Res.* **2016**, *5*, 433–452. [CrossRef]
11. Azmi, D.I.; Ahmad, P. A GIS Approach: Determinant of Neighbourhood Environment Indices in Influencing Walkability between Two Precincts in Putrajaya. *Procedia Soc. Behav. Sci.* **2015**, *170*, 557–566. [CrossRef]
12. Jin, J.; Paulsen, K. Does accessibility matter? Understanding the effect of job accessibility on labour market outcomes. *Urban Stud.* **2017**, *55*, 91–115. [CrossRef]
13. Moreno, C.; Allam, Z.; Chabaud, D.; Gall, C.; Pratlong, F. Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. *Smart Cities* **2021**, *4*, 93–111. [CrossRef]

14. Kowaleski-Jones, L.; Zick, C.; Smith, K.R.; Brown, B.; Hanson, H.; Fan, J. Walkable neighborhoods and obesity: Evaluating effects with a propensity score approach. *SSM Popul. Health* **2018**, *6*, 9–15. [CrossRef] [PubMed]
15. Su, S.; Zhou, H.; Xu, M.; Ru, H.; Wang, W.; Weng, M. Auditing street walkability and associated social inequalities for planning implications. *J. Transp. Geogr.* **2019**, *74*, 62–76. [CrossRef]
16. Tan, P.Y.; Samsudin, R. Effects of spatial scale on assessment of spatial equity of urban park provision. *Landsc. Urban Plan.* **2017**, *158*, 139–154. [CrossRef]
17. Bao, K.Y.; Tong, D. The Effects of Spatial Scale and Aggregation on Food Access Assessment: A Case Study of Tucson, Arizona. *Prof. Geogr.* **2016**, *69*, 337–347. [CrossRef]
18. Spyratos, S.; Stathakis, D. Evaluating the services and facilities of European cities using crowdsourced place data. *Environ. Plan. B Urban Anal. City Sci.* **2017**, *45*, 733–750. [CrossRef]
19. Boakye-Dankwa, E.; Nathan, A.; Barnett, A.; Busija, L.; Lee, R.S.Y.; Pachana, N.; Turrell, G.; Cerin, E. Walking behaviour and patterns of perceived access to neighbourhood destinations in older adults from a low-density (Brisbane, Australia) and an ultra-dense city (Hong Kong, China). *Cities* **2019**, *84*, 23–33. [CrossRef]
20. Carr, L.J.; Dunsiger, S.I.; Marcus, B.H. Walk score as a global estimate of neighborhood walkability. *Am. J. Prev. Med.* **2010**, *39*, 460–463. [CrossRef]
21. Weng, M.; Ding, N.; Li, J.; Jin, X.; Xiao, H.; He, Z.; Su, S. The 15-minute walkable neighborhoods: Measurement, social inequalities and implications for building healthy communities in urban China. *J. Transp. Health* **2019**, *13*, 259–273. [CrossRef]
22. Zhang, Z.; Fisher, T.; Feng, G. Assessing the Rationality and Walkability of Campus Layouts. *Sustainability* **2020**, *12*, 10116. [CrossRef]
23. Su, S.; Pi, J.; Xie, H.; Cai, Z.; Weng, M. Community deprivation, walkability, and public health: Highlighting the social inequalities in land use planning for health promotion. *Land Use Policy* **2017**, *67*, 315–326. [CrossRef]
24. Li, Z.; Han, Z.; Xin, J.; Luo, X.; Su, S.; Weng, M. Transit oriented development among metro station areas in Shanghai, China: Variations, typology, optimization and implications for land use planning. *Land Use Policy* **2019**, *82*, 269–282. [CrossRef]
25. Bloom, D.E.; Chen, S.; Kuhn, M.; McGovern, M.E.; Oxley, L.; Prettner, K. The economic burden of chronic diseases: Estimates and projections for China, Japan, and South Korea. *J. Econ. Ageing* **2020**, *17*, 100163. [CrossRef]
26. Su, S.; Li, Z.; Xu, M.; Cai, Z.; Weng, M. A geo-big data approach to intra-urban food deserts: Transit-varying accessibility, social inequalities, and implications for urban planning. *Habitat Int.* **2017**, *64*, 22–40. [CrossRef]
27. Xu, M.; Xin, J.; Su, S.; Weng, M.; Cai, Z. Social inequalities of park accessibility in Shenzhen, China: The role of park quality, transport modes, and hierarchical socioeconomic characteristics. *J. Transp. Geogr.* **2017**, *62*, 38–50. [CrossRef]
28. Hu, L.; He, S.; Han, Z.; Xiao, H.; Su, S.; Weng, M.; Cai, Z. Monitoring housing rental prices based on social media: An integrated approach of machine-learning algorithms and hedonic modeling to inform equitable housing policies. *Land Use Policy* **2019**, *82*, 657–673. [CrossRef]
29. Wang, Q.; Lan, Z. Park green spaces, public health and social inequalities: Understanding the interrelationships for policy implications. *Land Use Policy* **2019**, *83*, 66–74. [CrossRef]
30. Komossa, F.; Wartmann, F.M.; Verburg, P.H. Expanding the toolbox: Assessing methods for local outdoor recreation planning. *Landsc. Urban Plan.* **2021**, *212*, 104105. [CrossRef]
31. Plieninger, T.; Bieling, C.; Fagerholm, N.; Byg, A.; Hartel, T.; Hurley, P.; López-Santiago, C.A.; Nagabhatla, N.; Oteros-Rozas, E.; Raymond, C.M.; et al. The role of cultural ecosystem services in landscape management and planning. *Curr. Opin. Environ. Sustain.* **2015**, *14*, 28–33. [CrossRef]
32. Mehaffy, M.W.; Porta, S.; Romice, O. The "neighborhood unit" on trial: A case study in the impacts of urban morphology. *J. Urban. Int. Res. Placemaking Urban Sustain.* **2014**, *8*, 199–217. [CrossRef]
33. Brody, J. How ideas work: Memes and institutional material in the first 100 years of the neighborhood unit. *J. Urban. Int. Res. Placemaking Urban Sustain.* **2015**, *9*, 329–352. [CrossRef]
34. Fan, P.; Wan, G.; Xu, L.; Park, H.; Xie, Y.; Liu, Y.; Yue, W.; Chen, J. Walkability in urban landscapes: A comparative study of four large cities in China. *Landsc. Ecol.* **2017**, *33*, 323–340. [CrossRef]
35. Bereitschaft, B. Equity in neighbourhood walkability? A comparative analysis of three large U.S. cities. *Local Environ.* **2017**, *22*, 859–879. [CrossRef]
36. Gilderbloom, J.I.; Riggs, W.W.; Meares, W.L. Does walkability matter? An examination of walkability's impact on housing values, foreclosures and crime. *Cities* **2015**, *42*, 13–24. [CrossRef]
37. Jun, H.-J.; Hur, M. The relationship between walkability and neighborhood social environment: The importance of physical and perceived walkability. *Appl. Geogr.* **2015**, *62*, 115–124. [CrossRef]
38. D'Alessandro, D.; Valeri, D.; Appolloni, L. Reliability of T-WSI to Evaluate Neighborhoods Walkability and Its Changes over Time. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7709. [CrossRef]
39. Khattak, A.J.; Rodriguez, D. Travel behavior in neo-traditional neighborhood developments: A case study in USA. *Transp. Res. Part A Policy Pract.* **2005**, *39*, 481–500. [CrossRef]

40. Song, Y.; Merlin, L.; Rodriguez, D. Comparing measures of urban land use mix. *Comput. Environ. Urban Syst.* **2013**, *42*, 1–13. [CrossRef]
41. Artigues, G.; Mateo, S.; Ramos, M.; Cabeza, E. Validation of the Urban Walkability Perception Questionnaire (UWPQ) in the Balearic Islands. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6631. [CrossRef] [PubMed]